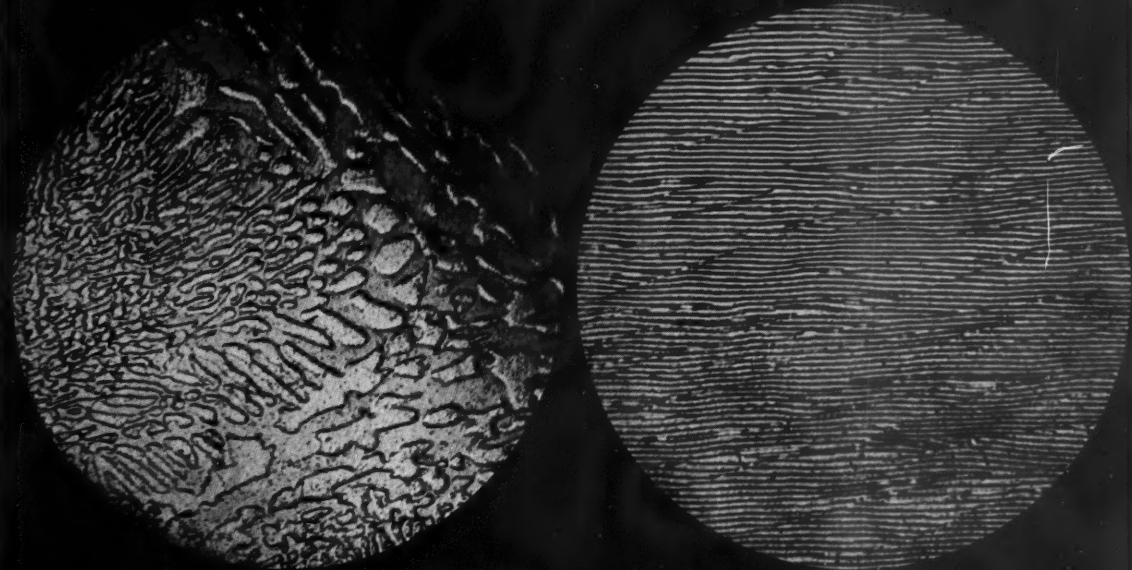
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

JULY 1960

Is a <u>FUNDAMENTAL</u> Research Program Worthwhile?



Normal binary eutectic structure (250X)

New binary eutectic structure (250X)

We, at the Research Laboratories, are convinced that it is worthwhile. For example, one of the fundamental scientific programs being undertaken is a study of the mechanism of solidification of polyphase alloys.

This study is still in its early stages. However, we now have a better understanding of the solidification process. And we have demonstrated that the microstructure of certain eutectics can be significantly altered by controlled solidification. The contrast is illustrated above.

It is possible that these binary alloys with preferred orientation may have unusual physical and mechanical properties.

Perhaps you are interested in corporate—sponsored studies into the fundamental nature of matter. If so, we can offer a research environment that seems to stimulate scientists to extra achievement. It may be due to the way we encourage an internal cross-fertilization of ideas; or because of a unique complex of complementary services that free the scientist from routine analysis and experimental chores.

Opportunities for scientists in the physics of solids, liquids, gases, and plasmas. Current studies range from the fundamental properties of matter to the application of scientific knowledge to promising new products.

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For more specific information, please write to Mr. F. W. Walsh, at the Research Laboratories.

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Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY INC.

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EDITORIAL

ASTRONAUTICAL REPORT—Part III

FEATURES

NEWS

ARS SEMI-ANNUAL MEETING

EDUCATION

DEPARTMENTS

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Astro notes

MAN IN SPACE

• Project Mercury's flight-test tempo is expected to pick up this month. The last Little Joe to be fired from Wallops Island is scheduled to carry a chimpanzee supported by the Mercury environmental system, instead of an independent biopac used in previous shots. Also scheduled for a July launching is a second Big Joe, this time using McDonnell's first production capsule, MA-1, instead of a boilerplate model. The Big Joe shot will be a maximum-abort reentry to qualify the capsule under the toughest imaginable conditions. No primate will be carried, but a black box simulating human respiration, moisture, and heat production will be carried to test the life-support system.

• Additional Atlas flights are scheduled for September (shallow-angle orbital re-entry) and early November (actual insertion into orbit with immediate re-entry). A chimpanzee supplied by Holloman will probably be inserted in the capsule late this year or early 1961 for a dress rehearsal of the three-orbit, 4.5-hr manned flight to come next year.

• The Redstone suborbital program has slipped four to six weeks, so the first shot is not expected until September. A simian will be carried in the second or third Redstone, with a man in the fourth, or possibly in the third if the first two shots work flawlessly. Space Task Group officials at Langley feel there is only a slim chance of meeting NASA Administrator T. Kieth Glennan's December 1960 date for the first manned Redstone flight in the Mercury program.

• The Astronauts are rapidly generating the new slang of manned space flight. For example, the red button which triggers the capsule's abort escape maneuver in event of a malfunction is called the "chicken switch."

• Under contract to the USAF School of Aviation Medicine, Spacelabs Inc. is developing a lightweight skin-tight vest with instruments for monitoring and transmitting an astronaut's heart action, respiration, temperature, etc. Known as "Biotel," the vest includes a battery-powered telemetry unit.

• GE's Missile and Space Vehicle Dept. is studying the preservation of food in spacecraft under a $50,000 contract with WADD. A working model of a proposed space "refrigerator" will be produced by MSVD as part of the study, called Frost.

• The two six-man SAC crews that each recently spent 15 days in a simulated space cabin 18 x 6 x 6 ft at Lockheed's Marietta plant, in an ARDC study of performance efficiency and psychological reaction to confinement, apparently went through the ordeal with a minimum of strain. There is a report, however, that participants in such experiments still continue to be plagued by upsetting hallucinations.

• The Russians encountered their first malfunction in space which was fully visible to Western eyes. The 5-ton spacecraft the U.S.S.R. launched into a 91-min orbit in May carrying a "dummy" astronaut separated a pressurized 2.5-ton capsule from the instrument section; but when the retrorockets were fired to re-enter the capsule, they pointed in the wrong direction and merely placed the capsule in a higher orbit. It is not surprising that the Russians are running into the same troubles that have plagued the Discoverer program. Because of the sheer size of their experiment, however, the Russians should be able to provide a relatively rapid identification and solution of the trouble.

• Initial phase of testing effects of low-frequency vibrations on human performance has started at Boeing's Wichita, Kan., Div., under an ONR contract.

SPACE TECHNOLOGY

• Pioneer V crossed the 14-million-mile mark early last month with its 5-watt signal still audible at Jodrell Bank's 250-ft radio telescope. Operation of the 150-watt transmitter was abandoned because loss of battery capacity brought the under-voltage relay switch into action during power surges, thus ending the transmissions. NASA scientists say the scientific content of Pioneer V's transmission is no longer intelligible, but they expect the signal to be audible to perhaps 20 million miles at Jodrell Bank.

• Tiros I, best-behaved of all NASA satellites to date, continued to relay pictures of the earth's cloud cover from its nearly circular orbit of 380 n.mi. By early last month, more than 20,000 had been received. The one Tiros malfunction—failure of the timer for the narrow-angle camera—repaired itself in May, thus assuring both wide and narrow-angle weather pictures. (This prompted one NASA wag to dub Tiros the U-3.) As expected, magnetic damping slowed the satellite's spin rate to 9.4 rpm. A command from Fort Monmouth late in May ignited a pair of spin rockets on the 270-lb satellite, raising its spin to almost 13 rpm.

• The AF succeeded in orbiting a 5000-lb Midas experiment on its second attempt (first failed in February), but the infrared-sensing satellite experienced a telemetry failure almost immediately. Purpose of the shot was to obtain a detailed infrared portrait of the earth at 300 miles altitude. Valuable data were obtained, but the satellite broke down before it could be tested against intense magnesium flares to be set off at Edwards and Vandenberg Air Force bases. It also missed an opportunity to detect a Titan takeoff at Cape Canaveral.

• The central problem in the Samos reconnaissance satellite program is not so much obtaining detailed pictorial data in the satellite, but rather the task of returning the information to the earth. First Samos satellites will utilize television techniques to relay information to readout stations in Oregon, Iowa, and New Hampshire, but because of bandwidth limitations the pictures must be very small in relation to conventional 9- x 9-in. aerial photos. This in turn imposes an extremely rigid pointing requirement on the satellite as well as an elaborate ground programming system. (See the series of articles by Amrom Katz curently running in *Astronautics*.)

• Magnitude of the AF program to develop warning and reconnaissance satellites can be seen from the following funding levels for the total Discoverer-Midas-Samos program: $357 million for all years up to July 1959; $299 million for fiscal 1960; and $333 million requested for fiscal 1961, which began July 1.

• The USAF Special Weapons Center, Kirtland AFB, N.M., announced a five-shot program with

its new four-stage Journeyman rocket. The 40-ft vehicle will carry radiation detectors to altitudes of 25,000–30,000 miles, thus penetrating both the inner and outer zones of intense Van Allen radiation. The first shot was scheduled for May, but the whole program has slipped about two months, the AF reports. Journeyman's stages include a Thiokol XM-33 motor, an X-254 built by Allegany Ballistics Lab, an Aerojet 30 KS motor, and a 150-lb spherical motor built by the Naval Ordnance Test Station.

• The first experimental attempt to correlate satellite instrumentation by broadcasting a standard timing code over NBS station WWV has been taking place in a cooperative program by NBS-Boulder, the Electronic Engineering Co., and Convair-Astronautics. This will give time accurate to 1 ms on an oscillograph.

• The Philco 2000 Computer, the first all-transistorized computer system, plays a major role in AF plans for space communications and in predicting satellite orbits. It has provided real-time control of the 15-ton three-axis antenna of the Telemetry and Data installation at Palo Alto, Calif., from Philco's Western Development Labs in the city.

• The AF will receive nine test vehicles under its recently announced contract with Aeronutronic for construction and test of the Hyper-Environmental Test System 609A, a version of NASA's Scout.

• GE's Space Sciences Lab of MSVD will continue research on the vacuum pyrolytic catalysis of human wastes to produce potable water under a $94,000 contract with NASA. The technique, not requiring chemical additives or filters, will be tested first with animals.

• MSVD will also do research and development of electrical power systems for long space flights under more than a million dollars in new contracts with the AF and Army: $697,000 from AFCRC for thermionic converter research; $300,000 from WADD for development of a solar thermionic power system; and $58,574 from the Signal Corps for development of a regenerative fuel cell.

• Bids are out for a dynamic test facility, including a steel test tower 204 ft high, for the Saturn development program.

• The AF is working on the idea of using rockets to provide emergency long-range communications should conventional radio links be blacked out.

• Project Banshee, which is expected to provide information for the development of anti-missile missiles and satellite "downing" techniques, will be tested next spring under joint sponsorship of the Army, Navy, and AF.

SPACE SCIENCE

• Jupiter's radio noise appears to be the result of a Van Allen type of radiation belt 100 trillion times stronger than the one surrounding earth, according to the California Institute of Technology. Using its twin 90-ft radio telescopes, financed in part by ONR, CalTech scientists found that Jupiter's radiation belt is the result of the synchrotron motion of electrons trapped in the huge planet's magnetic field, which parallels its axial rotation as does the earth's. Polarization studies of Jupiter's radio output show that the belts extend outward 200,000 miles over the equatorial regions.

• North American's Columbus Div. won a $9,100,000 contract to build the 600-ft reflector dish for the Navy's huge radio telescope at Sugar Grove, W. Va. It will work with a group of general contractors —Tidewater, Kiewitt, and P.E.C.— in fabricating and assembling the 7-acre aluminum antenna. Besides its great value for astronomical research, the fully steerable instrument will have important military reconnaissance capability by tuning into radiation reflected off the moon. One possibility—location of Soviet ballistic-missile sites by pinpointing radio guidance patterns.

• The Naval Research Laboratory will make another attempt in October to obtain a detailed ultraviolet picture of the night sky with an Aerobee-Hi rocket. A shot from White Sands late in May was only partially successful. Although the rocket reached an altitude of 135 miles and rolled as programmed, so its eight mirrors could scan the sky, a spark or coronal discharge in the power supply ruined all but one or two bands of telemetry. It is believed valuable information was received above the Lyman-Alpha wavelength at 1216 Å.

• From an analysis of balloon and satellite studies, J. R. Winckler of the Univ. of Minnesota, writing in the IGY Bulletin, suggests that cosmic rays may be produced by a synchrotronic mechanism associated with solar flares, stored in the vicinity of the sun, and finally channeled toward the earth in a cloud of plasma ejected by the flare. At the same time, magnetic fields in the plasma, he believes, deflect away from the earth the higher-energy galactic cosmic rays.

• Tiros I data indicate that great storms in the middle latitudes show the same banded, inward-spiralling structure known to characterize tropical storms.

• Arma Div. engineers turned a neat trick in measuring the rotation of the earth for the first time by inertial means, using an Atlas guidance system accelerometer and American Bosch Arma's very precise centrifuge.

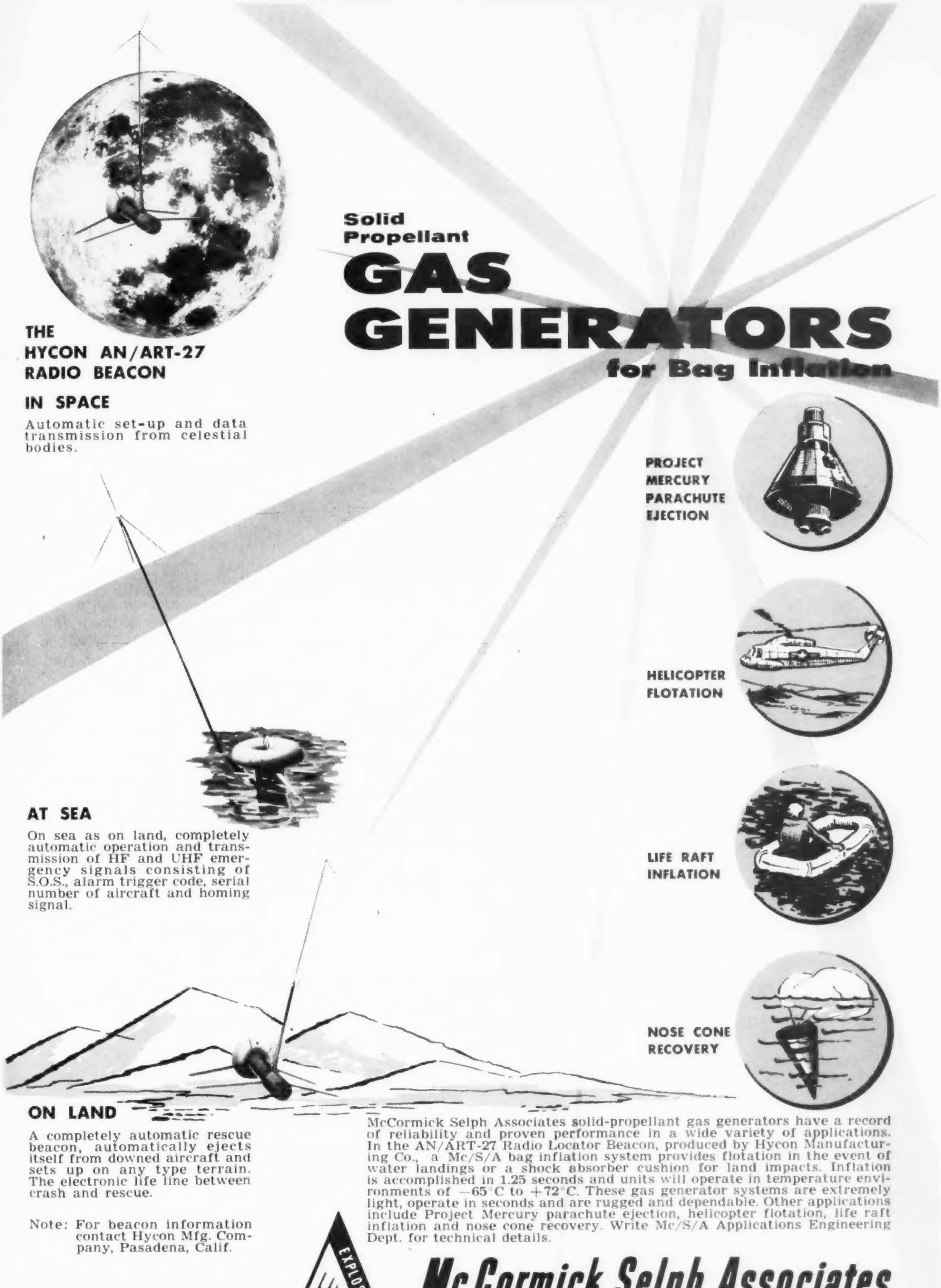
• NASA will establish a new Life Sciences Research Center, with work centered in three areas—flight medicine and biology (applied area), the space medical and behavioral sciences (neurophysiology, psychiatry, etc.), and space biology (ground-based studies at the cellular and subcellular levels). Location of the Center has not as yet been selected, but present plans call for a 90,000-sq-ft building and a staff of some 60 professionals.

• The NASA life sciences program has already generated such projects as the development of a "space census taker." ARS member Joshua Lederberg of Stanford Univ., Nobel Prize winner in genetics, is working on a device that will identify life forms with the aid of an automatic microscope and vidicom.

EXTRATERRESTRIAL LIFE

• Latest suggestion in the search for extraterrestrial life comes from Freeman J. Dyson, a physicist at the Princeton Institute of Advanced Study. Besides listening for radio signals outside our solar system, he proposes that a search be made for point infrared emissions in the 10-micron region, possibly unaccompanied by a visible light source. A large thinker by any standard, Dyson speculates that such radiation might be produced by an artificial shell several hundred million miles in diameter which a race of intelligent creatures might build around their parent star to make use of all of its energy and all the living space available in their solar system.

• Using man's own solar system as a model, Dyson observes that the mass of Jupiter could form a spheri-



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GAS
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McCormick Selph Associates solid-propellant gas generators have a record of reliability and proven performance in a wide variety of applications. In the AN/ART-27 Radio Locator Beacon, produced by Hycon Manufacturing Co., a Mc/S/A bag inflation system provides flotation in the event of water landings or a shock absorber cushion for land impacts. Inflation is accomplished in 1.25 seconds and units will operate in temperature environments of −65°C to +72°C. These gas generator systems are extremely light, operate in seconds and are rugged and dependable. Other applications include Project Mercury parachute ejection, helicopter flotation, life raft inflation and nose cone recovery. Write Mc/S/A Applications Engineering Dept. for technical details.
EXPLOSIVE
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cal shell around the sun 2 to 3 meters thick at a distance of twice the earth's from the sun, and with appropriate machinery could exploit all the radiation falling upon its inner surface. It could support a population a trillion-fold greater than the earth's present population—a level which could be achieved in 3000 years at a 1 percent annual rate of growth.

MISSILES

• The U.S. has agreed to supply British V-Bombers (Victor, Valiant, and Vulcan) with the Skybolt air-launched ballistic missile, when it becomes operational in 1964. In a "minute of understanding" negotiated by Defense Secretary Thomas Gates and Defense Minister Harold Watkinson, the U.S. will train British aircrews and technicians in the handling of the 1000-mile-range weapon in this country. The agreement was silent on the use of ship based Polaris missiles by Britain.

• The AF succeeded in its oft-delayed attempt to send an Atlas nose cone 9000 miles down the Atlantic Missile Range into the southern Indian Ocean. The GE Mark III nose cone and 1000 lb of instrumentation fell approximately 1000 miles farther than the 8050 statute miles recently disclosed by the AF as the Atlas' maximum range. This means the long-legged Atlas could not have carried its full warhead over the same distance. The shot was the 51st for Atlas, including 32 successes, 8 partials, and 11 failures.

• The Martin Co. regards its Titan I as virtually developed, and is putting 90 percent of its Denver engineering effort into Titan II, the growth version of the weapon which will have storable propellants. First flight test of the J series of Titan vehicles (the operational version of Titan I) was scheduled for June at Cape Canaveral. Martin anticipates no difficulties, however, because the J series is cleaner and simpler than previous vehicles. The Titan scoreboard reads 12 successes, 2 partials, 2 failures. First Titan squadron will become operational at Lowry AFB, Colo., next June.

• Titan II will be considerably larger than Titan I, standing 110 ft in height to the latter's 98 ft, and having more than 400,000 lb of takeoff thrust against Titan I's 300,000 lb. Its second stage will be 10 ft in diam instead of 8 ft, and it will be able to haul a warhead of twice the yield of Atlas over a range of 9775 statute miles. The use of nitrogen tetroxide and hydrazine propellants will eliminate the costly quick-loxing facilities required for the first-generation liquid missiles, while the ability to fire directly from the underground silo will eliminate the need for expensive elevators. Thus the larger Titan II will have an estimated cost per squadron of $138 million, against $167 million for Titan I.

• The AF announced that its first Minuteman squadron at Malmstrom AFB, Mont., will have 55 weapons located in underground silos distributed among three adjacent counties. A construction contract is expected early next year (see page 34). The complex is expected to be completed by mid-1962 at a cost of about $20 million.

• Flying the longest ballistic trajectory over land in the U.S.—more than 120 miles over the White Sands range—a combat-version Redstone missile recently tested the TV apparatus designed to give battlefield commanders an aerial view of the target before, during, and after impact of the missile's warhead.

• Future Zeus tests will be of a tactical configuration. The Army is channeling $18 million more of its funds into the Zeus program.

• The Army successfully flight-tested its jet-powered surveillance drone at the Electronics Proving Ground in Arizona. The turbojet drone was designed and built by Fairchild Engine and Airplane.

• Both Boeing and Space Electronics Corp. are investigating the use of earth currents for long-range communications in controlling missile launches and other military action in the field.

PROPULSION

• North American's Rocketdyne Div. edged out GE, Bell, Aerojet-General, and Pratt & Whitney Div. of United Aircraft for the coveted contract to develop a 200,000-lb-thrust liquid-hydrogen rocket engine for the second stage of the C-2 version of Saturn (see page 26). NASA said it expects the work to cost $44 million and require three years. The C-2 is a four-stage vehicle including the clustered 1.5-million-lb first stage, a new second stage propelled by a pair of the "200 K" Rocketdyne engines, a third stage propelled by four P&W lox-hydrogen engines totaling 80,000 lb, and a fourth stage consisting of the Centaur vehicle. C-2 should be available in the late 1960's, NASA said.

• Saturn's first-stage engine cluster has been successfully static-fired for up to 30 sec at Huntsville, Ala. Witnesses report that the sound of all eight engines firing together is distinctly lower in pitch than when the engines are fired individually in a Thor or Jupiter rocket.

• Martin Co. is angling for a space-booster assignment for its Titan vehicles, but the only one forthcoming to date has been for Dyna-soar. Martin claims Titan I (SM-68A) can orbit 11,000 lb, including 5000 lb of payload, while Titan II (SM-68B) can loft 10,000 lb of payload. Unfortunately for Martin, the Atlas-Agena and Atlas-Centaur vehicles have been selected by the AF and NASA for booster tasks in this weight category.

• NASA awarded United Technology Corp., a subsidiary of United Aircraft, a contract to build three conical-shaped segmented solid-propellant rocket motors to determine whether this technique has value in the construction of extremely large solid-propellant motors. UTC claims its conical motor shapes eliminate erosive burning, which can occur in large cylindrical rockets. The AF, meantime, is still studying proposals for a very large solid rocket with a total impulse of 20 million lb-sec. The segmented approach was used by several companies in this competition.

• Hughes Aircraft won an NASA contract to design and build a cesium-ion engine capable of developing about 0.01 lb of thrust. The program will run one year and cost more than $500,000, NASA said. The Hughes motor measures 4 in. in diam and 8 in. in length. It would be used with the Snap-8 30-kw nuclear-power source presently under development by NASA and AEC for such tasks as orbital corrections and possibly unmanned interplanetary transits.

• Goodrich-High Voltage Astronautics Inc. received a WADD contract for development of a demonstration arc-type ion engine. Under a second AF contract, GHVA will make a concomitant study of an electrostatic generator for an ion engine.

• Aerojet-General has begun development work on a hybrid rocket motor under a $580,000 contract with the Navy's Bureau of Weapons.

PROPELLANTS

• Thiokol's Elkton Div. announced


Bouncing a voice through 2000 miles of space . . .
nother Philco achievement
global communications
part of a major study of space communications techques, Philco is prime contractor for an Air Force project relay high frequency radio communications around the rvature of the earth, through space. Known as the ssive Satellite Relay Link, it will reflect voice and telepe signals from a 100 ft. aluminum-skinned plastic balloon. der NASA's Project Echo, the balloon is to be launched o a 1,000 mile earth orbit for use as a passive commucations reflector.
The parametric amplifiers, receiving antennas, and track- and receiving systems are Philco designed, built and talled. The entire program is managed by Philco, under supervision of the Communications Directorate, Rome Development Center.
This is one more step in man's utilization of outer ace . . . and another important Philco achievement in bal communications. For capacity, facilities and expence in advanced electronic systems, look to the leader . . . k to Philco.
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Western Development Laboratories

development of a solid propellant that has been successfully static-tested in rocket engines at initial temperatures ranging from −85 to 300 F and after cycling from −65 to 200 F. The new propellant, based on hydrocarbons, is expected to be used in motors for the Hughes Falcon family of missiles, and was developed under contract with ARDC in association with Hughes . . . Elkton also has rocket engines under development for Subroc and the Project Mercury escape mechanism . . . Grand Central Rocket's nitrosol, in 4-lb packets, has withstood bullet impact without detonation, according to G. R. Makepeace, the company's vice president for research and engineering . . . Callery Chemical expects to begin production of pentaborane at the Muskogee, Okla., plant by late summer, according to its president, E. G. Sanner . . . American Potash and Chemical's National Northern Div. is making available pilot-plant quantities of guanidinium perchlorate, which can be used as an explosive or a monopropellant . . . Olin Mathieson's Energy Div. will produce jet starter cartridges under a new $1 million AF contract . . . Food Machinery and Chemical Corp. was awarded over $20 million for production of the storable liquid-propellant, unsymmetrical dimethyl hydrazine by the Air Force. The propellant will be produced in expanded FMC facilities at its Baltimore, Md., plant.

R&D

• An entire process for determining level-by-level net inventory requirements—complete without human intervention, including the automatic preparation of purchase requisitions and shop fabrication orders—has been put into operation by American Bosch, a division of American Bosch Arma Corp., with the aid of IBM's Data Processing Div. The so-called IBM Management Operating System, based on the use of the RAMAC 305, even follows the activities of salesmen in the field in its manifold linking of materials planning, inventory, management, scheduling, dispatching, operations evaluation, and forecasting. According to Gilbert E. Jones, president of IBM's Data Processing Div., the Management Operating System borders on being a machine which learns and thinks with internal independence. Norbert Wiener, commenting again on such machines in the May 6 issue of *Science*, suggests that they may develop unforeseen strategies at rates that baffle their programmers.

• Minneapolis-Honeywell Regulator Co.'s Aeronautical Div. announced the successful application of precision ceramic parts to miniaturized gas-bearing gyroscopes, with new highs in performance. M-H expects the new gyro to find immediate use in space vehicles.

• The development of a 15-kw Rankine-cycle turbogenerator power system is contemplated in the study contract recently awarded Sundstrand Turbo by WADD. This system would employ a solar collector for space applications. Contemplated total weight, about 900 lb. Sundstrand estimates a $12-million program spread over five years will be necessary to produce a system for flight testing in space.

• Early last month, an Atlas was guided 5000 miles down the Atlantic Missile range by the American Bosch Arma inertial system, in the first fully inertial guided flight of a U.S. ICBM. The test was completely successful.

• Chance Vought will continue to develop the SLAM guidance system under a $650,000 ARDC contract . . . Hoffman Electronics has been issued a patent covering shingled solar cells . . . Transitron reports raising silicon solar cell efficiency to 15 per cent . . . Norair's Science Center is studying the possible application of thermonuclear reactions for spacecraft propulsion . . . The Univ. of Michigan's College of Engineering has instituted a long-range program on the behavior of ionized gases at very high temperatures . . .

• Amcel Propulsion Inc., a subsidiary of Celanese, began occupying its new research laboratory at Ashville, N.C., last month . . . Thiokol established a group at Parsipanny, N.J., to study and do research on nuclear propulsion for spacecraft . . . The Bendix Corp. is now the name of the parent Bendix company . . . Nortronics launched a new Systems Support group with special underground facilities for ordnance and countermeasures development and testing . . . Thompson Ramo Wooldridge dedicated its Colwell Engineering Center in Cleveland, Ohio, last month; the new facility will ultimately cost over $5 million; the Tapco Group's materials development team moves in first . . . The emergence of Aerospace Corp. as a successor to STL was expected last month . . .

• Project Advent bidding began in June. Under ARPA leadership, the Advent program involves three real-time satellites in 24-hr orbits.

INTERNATIONAL

• William Bergen, president of the Martin Co., speaking at the National Industrial Conference Board's 44th Annual Meeting, asserted that the leaders of the U.S. missile and space industries would welcome world disarmament as an opportunity to press the exploration of space. "I firmly believe," he said, "that when and if the U.S. lays down the heavy financial burden of its present weaponry insurance policy against war, it will make the same investment—and more—in the peaceful exploration of space."

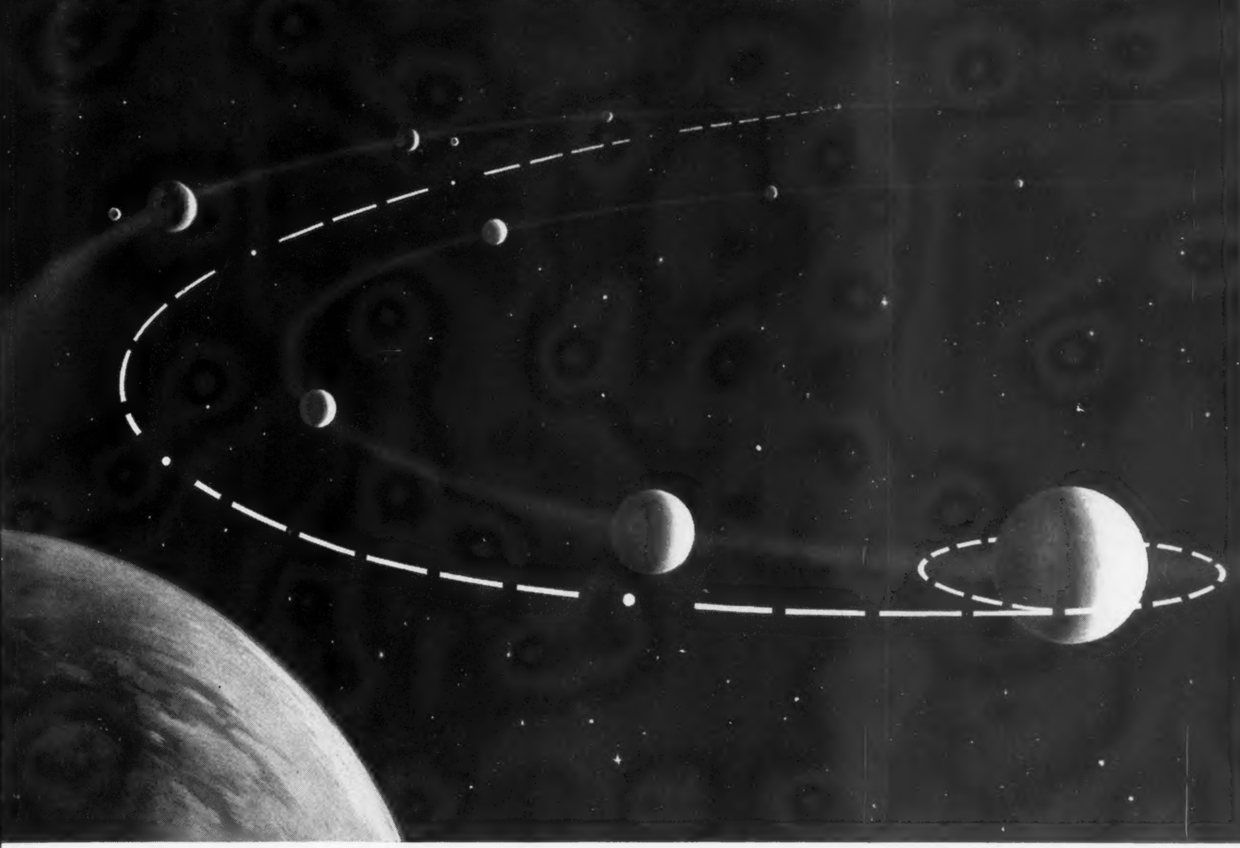
• West Germany is prepared to launch a German-built rocket as a part of the international space program next fall.

• The IAF and the Daniel and Florence Guggenheim Foundation announced jointly the formation of an International Academy of Astronautics. T. von Karman, L. Sedov, A. G. Haley, and H. F. Guggenheim have urged the interest and support of the astronautics community in this new institution. ARS President Howard Seifert comments on the International Academy in his editorial this month (see page 21).

CONTRACT BRIEFS

• Convair will continue production of Atlas for the weapon system and as a space booster under a new $118 million contract with the AF . . . Convair-Astronautics awarded the Siegler Corp. a $15 million contract for automatic Atlas launch control-equipment . . . Thiokol received an additional $7.3 million for production of motors and plant maintenance at Longhorn . . . Raytheon received $13.5 million for Hawk ground equipment and $3.5 million for training and documentation work . . . Raytheon also continues development of Sparrow III under a new Navy contract for $3.1 million . . . The Army awarded Martin-Orlando a supplemental agreement contract for $2.7 million for work on the Pershing missile system, which brings total Pershing funding to $208,766,034 . . . General Precision was appointed navigation subsystem manager for the AF Airborne Long Range Input (ALRI) program, being managed by Burroughs, and will receive a $3.5 million contract . . . AC

A possible Earth to Venus Trajectory (dotted line) for 107-day flight programmed for burnout conditions over Cape Canaveral on 16 January 1961 at 15.65 hours (ephemeris time). Illustration shows positions of Earth, Venus, vehicle at eighteen-day intervals.



MISSILE AND SPACE VEHICLE DEPARTMENT

...center for missile and space technology research and development at General Electric

Progress in defining space trajectories

Astrodynamicists at General Electric's Missile and Space Vehicle Department are currently mapping space . . . determining trajectories for flights from the Earth to other bodies of our solar system.

Under these funded studies, MSVD has recently completed a program of error analysis of trajectories to the Moon involving the four-body gravitational system, as well as a study of flight paths to Venus.

From consideration of the total gravitational field, specific space missions are computed when date of departure, trip time and launch site are specified. The exact launch burnout conditions are determined for the time of day which maximizes the additional boost caused by the Earth's rotation. Employing new techniques, MSVD scientists have made these determinations with as few as three corrective computer runs. These methods also can be applied to flights to other planets of our solar system.

In addition, the Department is developing methods to determine orbital parameters of earth satellites using only Doppler information. This MSVD experience in tracking techniques and computer programs permitted analysis of the Russian Lunik III trajectory.

For more information about MSVD's progress in all phases of space technology, write for the new Department Bulletin, Section 160-92, General Electric Co., Missile and Space Vehicle Department, Philadelphia 1, Penna.

GENERAL ELECTRIC

MISSILE AND SPACE VEHICLE DEPARTMENT

A Department of the Defense Electronics Division

Scientists and Engineers interested in career opportunities in Space Technology, contact Mr. T. H. Sebring, Dept. 160, MSVD

Spark Plug will supply the inertial platform for the ALRI system . . . Chance Vought's Astronautics Div. was awarded a \$1.7-million contract for construction of the airframe and special support equipment for the AF's version of Scout . . . JPL selected Space Electronics Corp. to produce flight decoders, digital data systems, and related equipment, and issued a \$450,000 contract for the work . . . Electro-Optical Systems Inc. will work on a molecular-electronic tunable amplifier under a \$83,988 contract with WADD . . . Hoffman Electronics will fabricate 12 solar-cell panels for the Ranger program under a \$548,000 contract to JPL.

• Metallic seals for hydraulic systems of advanced AF flight systems will be developed by Republic Aviation for WADD under an \$80,000 contract; specs call for leakproof operation between −320 and 800 F . . . Burroughs awarded Packard Bell Electronics a \$450,000 design and manufacturing contract for the ALRI identification subsystem . . . Telecomputing Corp. will design and develop a two-axis free gyro for the Army's Shillelagh missile under subcontract to Aeronutronic . . . The AF selected Bendix Corp. to produce the initial version of the Skybolt automatic ground check-out system under a \$1.5 million contract . . . Aircraft Armaments Inc. was selected by the Smithsonian Astrophysical Observatory as system manager for the rocket payload and ground station for Project Celoscope, which involves the use of an Aerobee-Hi to take data on intensity of ultraviolet stellar radiation; the system will include a TV and RF subsystem provided by TRW's Dage Television Div., and is scheduled for delivery in six months . . . Photronics Corp. will design and fabricate for the Navy a high-acuity aerial reconnaissance lens, models of which give an average laboratory resolution better than 200 lines/mm . . . Stromberg-Carlson will produce some \$4 million in special radio equipment for antisubmarine warfare for BuWeapons . . . Motorola Semiconductor Products Div. will develop high-reliability mesa transistors for the Minuteman program under subcontracts totaling \$1.272 million to Autonetics, prime contractor for the inertial guidance and flight-control systems . . . Bulova Watch will produce \$110,000 worth of Zuni fuzes under Navy contract . . . Lear Instrument Div. will produce \$8.2 million of gyroscopic indicating systems for the AF's MARS master attitude reference . . . Under a \$1.925 million subcontract to Convair-Pomona, Raytheon's Equipment Div. will develop electronic controls that will make it possible to fire the Army's Mauler missile in motion . . . GE's Heavy Military Electronics Dept. will produce long-range height-finding radar (AN/-SPS-30) for the Navy under a new \$14 million contract; the radar detects range, azimuth, and height . . . The J. W. Fecker Div. of American Optical Co. will design, make, and install a long-focal-length tracking telescope for NASA-Langley (Wallops Island) under a \$300,-000-plus contract; the tracking system will be similar to Fecker's Igor Mk II . . . The range equipment at the south end of White Sands will be modernized by Cook Electric Co., with consultation by Remington Rand Univac Div. and SPAR Corp., under a new contract that in effect doubles Cook's work on AR-TRAC . . . The Pacific Scatter Communication System, developed and installed for the Army by Page Communications, has become operational, with eight stations blanketing a 6500-mile range . . . As of June 30th, \$106 million will have been spent on the Defender program; more than \$110 million in funding is planned for fiscal year 1960 . . . The aircraft industry's earnings in 1959, reflecting the shift to a new era of engineering development and production (see page 87), fell to a new low of 1.5 percent of profit on sales, according to the Securities and Exchange Commission; the industry showed a return of 8.0 percent on net worth, as compared to an average of 9.6 percent for all manufacturers.

MATERIALS

• Universal-Cyclops Steel Corp. opened its now operating InFab facility, developed in cooperation with the Navy's BuWeapons, for inspection. Largely automatic and employing an artifical atmosphere of argon gas, the InFab facility produces mill products of refractory metals such as molybdenum, columbium, tantalum, tungsten, and alloys of these . . . Alcoa announced development of a group of aluminum-iron-nickel alloys that withstand corrosion by high-purity water at temperatures up to nearly 700 F . . . Molybdenum fibers added to uranium dioxide powder improves its thermal conductivity in the form of nuclear fuel elements by 30 percent and more, according to engineers of Martin-Baltimore . . . Republic Aviation's Missile Systems Div. has developed and patented a method of joining dissimilar metals in a rocket motor case by bonding overlapping seamless rings with adhesive . . . Republic's engineers have also developed a special alloy of beryllium and copper as a hot-cooling material; applications include precision casting of dies . . . National Research Corp. will study methods of producing refractory metals as ultrafine powders under a \$73,343 contract with the Navy's BuWeapons . . . Brush Beryllium was host for a symposium on properties and applications of beryllides in Cleveland early in June . . . Chance Vought's Aeronautics Div. has developed a process of precoating heat-treated metals with copper or aluminum, which forms an oxide coating and thus prevent burnoff of the base metal, holding tolerances . . . GE has developed an iron-nickel-cobalt alloy (Fernico-5) that has a thermal expansion coefficient much lower than those of metals and alloys commonly used in ceramic-to-metal seals. The company predicts that the new alloy will extend the use of alumina parts in electronic equipment for high-temperature operation.

• In an AIM symposium held early in June, Union Carbide Metals engineers reported that columbium alloys containing tungsten and titanium resist oxidation to a temperature of 2550 F with good mechanical performance . . . Artrite Resin, a British polyester manufacturer, has produced in its laboratories ceramic-like polyester resins that can withstand temperatures around 1000 C, according to G. Arder, a director of the company . . . Coatings of certain polar organic compounds on specimens of steel, magnesium, and copper-beryllium alloys markedly increased their fatigue strength, according to the NBS; the compounds found most beneficial have a carbon chain of at least 12 with a polar group at one end . . . Chance Vought received a \$486,000 AF contract for studying the forming of refractory metals and refining equations for engineering them . . . NASA has purchased a 150-kw electron beam melting and casting furnace for the Lewis Research Laboratory, will push research on casting of tungsten with it . . . Mobay Products Co. is showing its thermoplastic polycarbonate resin, a linear aromatic polyester of carbonic acid with a wide potential utility. ♦♦

For the record

The month's news in review

May 3—House Science and Astronautics Committee tentatively approves abolition of Civilian-Military Liaison Committee and National Space Council in favor of Astronautics Coordinating Board.

May 5—France fires four-stage rocket to 94-mile altitude.

May 6—AF Minuteman is successfully test-fired from underground silo.

May 8—NASA turns on and receives messages from Pioneer V's 150-watt transmitter as planetoid reaches 8,001,000 miles from earth.

—Navy-NSF announce plan to launch 100-ft-diam inflatable balloon in May or June.

—NASA successfully tests prototype of Mercury escape system.

May 10—Maj. Gen. Don R. Ostrander, NASA director of launch vehicle programs, says U.S. intends to launch 75 to 105 major space vehicles and probes by 1963 in move to overtake Soviets in space race (see page 22).

—NASA discloses that Pioneer V's big transmitter has sprung a leak.

—NASA reports a mechanical defect that prevented Tiros I from taking cloud pictures over the Soviet Union and China has corrected itself.

May 11—Army Signal Corps weather balloon sets nighttime altitude record of 144,000 ft, then bursts.

May 12—AF aborts first try at launching an Atlas 9000 miles.

May 13—NASA attempt to orbit Project Echo 100-ft inflatable communications balloon fails.

May 14—Navy christens missile-sub Abraham Lincoln.

May 15—Soviet Union orbits 10,000-lb satellite bearing model space cabin, weighing about 5500 lb, and equipped with a telephonic transmitting device.

—IAF and Guggenheim Foundation announce establishment of an International Academy of Astronautics to provide world technical leadership for peaceful exploration of space.

May 18—Navy successfully test fires Polaris 1000 miles from underground tube.

May 20—AF fires Atlas with $1^1/_2$-ton payload to record 9040 miles, exceeding by more than 1000 miles longest Soviet missile shot.

—House Appropriations Committee votes AEC \$58 million to expedite nuclear-powered plane work.

—Soviets report that its "space ship" launched May 15 entered a new orbit as consequence of firing a retrorocket and ejection capsule.

—AF says Soviet's Lunik III, launched last Oct. 4, has burned up on re-entry into earth's atmosphere.

May 24—AF Atlas boosts 5000-lb Midas (Missile Defense Alarm System) experimental satellite, 22 ft long and 5 ft in diam, into orbit.

May 25—Army successfully fires fifth and last old model of Nike-Zeus.

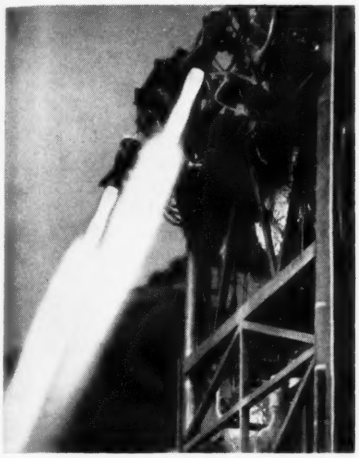
May 27—NASA ground command to Tiros I fires two of its spin rockets, boosting rotation about 3 rpm.

—AF says Midas' ground-to-orbit radio links are not functioning properly.

May 28—NSF discloses it will give universities basic research grants on a no-strings-attached basis, including freedom in directing and conducting research.

May 31—NASA 100-ft-diam plastic sphere, launched by sounding rocket, successfully opens at 200-mile altitude before falling back to earth. ♦♦

Vernier Rockets Run Record Time



Two Rocketdyne-developed vernier engines for Atlas run through a 1930-sec static firing—one of the longest ever made by a liquid-propellant engine. A key part of the vernier engine is the Flo-Ball dual propellant-metering valve produced by Hydromatics Inc.

Applying for NSF Senior Fellowships

Applications will be accepted through Oct. 10, 1960, by the National Science Foundation for the 375 fellowships to be awarded under its Senior Postdoctoral and Science Faculty Fellowship programs, which cover many fields.

To be eligible, applicants must be citizens of the U.S., possess special aptitude for advanced training, and have held the doctoral degree for at least five years or have equivalent education and experience.

Annual stipends to a maximum of $12,000—adjusted to match as closely as feasible the salaried income of the recipients as of the time of application—will be awarded under both of these programs.

Application material may be obtained from the Fellowships Section, Div. of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Completed material must be received not later than Oct. 10, 1960.

Goddard Biography Available

A short biography of American rocket pioneer Robert H. Goddard has just been printed by Avco RAD. Copies are available free of charge from Fred Durant, Avco RAD, Wilmington, Mass.

Careers in astronautics

By Irving Michelson, *Pennsylvania State University*

Of the great variety of human and material resources which play a role in the conquest of space, our main concern is with the newer activities and interrelationships of those professional engineers and scientists whose efforts culminate in vehicle hardware. It is therefore disheartening to note the paradox that the excellent working partnership that has developed between scientists and engineers has itself placed one of those partners in jeopardy in an accidental fashion.

For as space accomplishments multiply, press notices redound to the glories of—of what? Of science? Of engineering? Of the "new technology?" The truth is that the public mind has been conditioned to equate and identify the terms science, engineering, technology—used almost interchangeably in public announcements, particularly, of late, those pertaining to space developments. The layman's confusion, of course, derives from the fortunate fact that much progress in science and engineering can no longer be sharply identified as precisely in one domain or the other.

If the difficulty were merely a semantic one, the professionals and the public would do well enough to let sleeping substantives lie. But a very real difficulty seems to be developing which threatens the future of astronautics; that is, among the most capable graduates of the country's high schools, heightened interest in "science" has been a direct cause of diminished interest in "engineering." Dr. F. C. Lindvall of CalTech suggests this is due to the glamorization of science since World War II, to a degree far surpassing public recognition and realization of progress in engineering. Science is reaping—if unwittingly—the lion's share of national attention. As a result it has been seen that at CalTech, where the traditional breakdown between science and engineering has been roughly half and half, the latest figures quoted indicate only 21 percent declaring for engineering, while the percentages in physics and mathematics have increased sharply. The seriousness of the problem is that we foresee a continuing increase in the demand for well-trained engineers to perform tasks of a distinctly engineering character—and different indoctrinations do not provide satisfactory substitutes.

While our Soviet friends multiply their annual production of engineers by a factor of two, we must find ways to avoid the danger of using the same factor as a divisor. The urgent need is for the propagation of a more clear and accurate image of the engineer and his function in modern society. Dr. James Killian has urged this point, advocating that our great engineering accomplishments be more accurately identified and emphasized at the popular level.

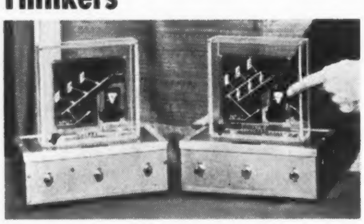
Foreshadowing, perhaps, the penalties to be paid for permitting an excessive shrinkage of engineering manpower, are the rumblings we hear from time to time of acute shortages in classical varieties of engineering talent required for current space programs. The Martin Co., for example, recently indicated a substantial need for structural analysts in conjunction with redesign of the Dynasoar booster, as well as dynamics and test engineers for the same program. In view of work which lies ahead on newer versions of Titan, Pershing, and other missiles, it is fortunate that these engineers can be drawn from less vital programs elsewhere.

The steady growth of Air Force R&D activity continues to place wholesale requirements for a variety of professional talents. WADD Headquarters indicates that recent reorganization within that division alone has created billets for upwards of 600 engineers, metallurgists, and health physicists. All degree levels are sought, with annual salaries ranging from less than \$5000 to about \$9000 (if ARDC has a little trouble recruiting, we could suggest a possible reason). Physical chemists and psychologists are also sought, with a somewhat lower ceiling on salary.

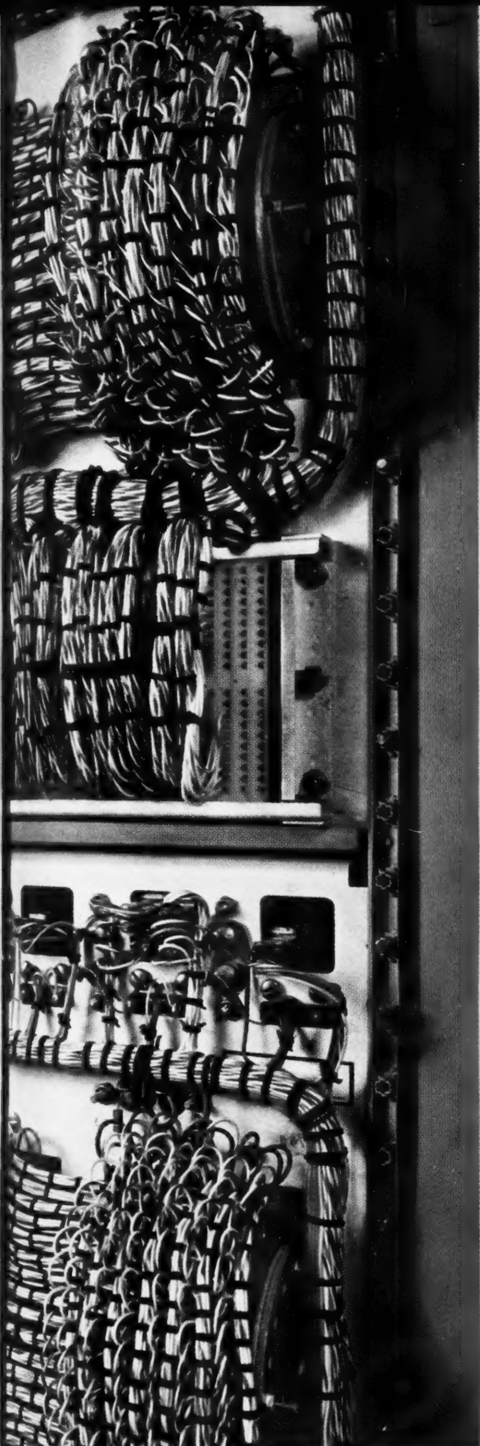
The science of "agratomics" is being pursued on an experimental basis for the purpose of determining the radiation dosage necessary to disrupt the reproductive cycle of living organisms. A subsidiary of the Marquardt Corp. is reportedly conducting tests on nematodes, which have long been of great interest in laboratory studies covering numerous generations of this type of worm. In the present instance there is a lively, nonmilitary, and very practical stimulus for this research, deriving from the fact that nematode crop damage is counted in the hundreds of millions of dollars each year. Space environment studies are of course also much concerned with radiation tolerances. It will also be interesting to see later on whether agratomics comes to be recognized as a pure science, an applied science, an engineering discipline, or some combination of these.

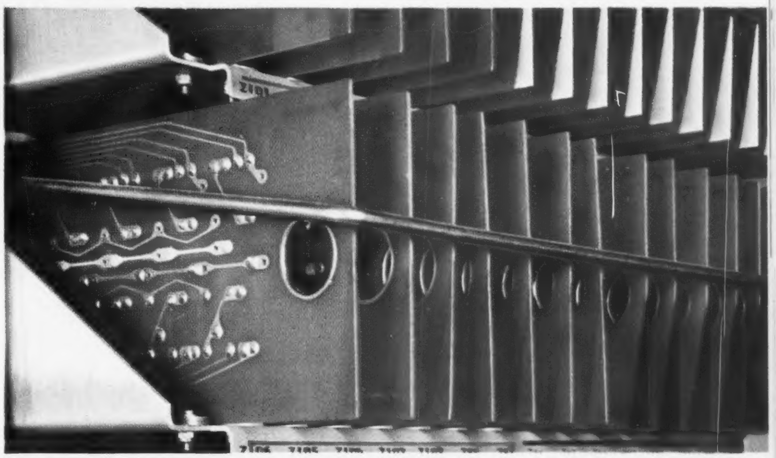
Perhaps we can dodge questions of this type for a while, as we notice what others are doing. The Maryland Section of ARS, for example, cooperated last Spring with the Univ. of Maryland in offering a Space Education Institute, broadly construed and perhaps deliberately not labeled as either science or engineering. Other educational programs suggest still different solutions, such as the short course labeled "Thermochemistry of Rocket Propulsion" being offered late this month at UCLA. The first word is suggestive of hybrid science (although we know its connotation has been particularly related to engineering science), the last words emphasizing the astronautical technology. While the contents of these fine programs (many others could be cited, too) represent the most proper synthesis of science and engineering, tending to obliterate the distinction, we are surely creating problems for the layman, the historian and philosopher of human progress, the journalist, and also for the guardians of our national security. ♦♦

Electroluminescent Thinkers



These compact, electroluminescent readout devices, developed by Sylvania, can perform the logic and memory functions of digital computers. Electroluminescence creates light through excitation of phosphors placed in an electrical field, eliminating the need for bulbs, vacuum, and filaments. The new devices are expected to have important design application in data processing, countermeasures, etc.





International scene

By Andrew G. Haley

Chinese Astronautical Research—Part III

ONE IMPORTANT field in which Chinese Communist scientists intend to move forward rapidly involves certain new techniques and important borderline sciences, such as nuclear technology, computer technology, semiconductors, radio-electronics, automation, chemical physics, biophysics, etc. All are developing rapidly, forming the spearhead of the science front in its march forward and new growth points for the development of scientific theories. In consequence, Du states, they are inevitably the domains where the Chinese will reap the richest harvests, and indicate the directions in which victories can be easily won. However, it is precisely in these directions that scientific forces are the weakest. Thus today, unless the Chinese concentrate their forces and especially those forces with the greatest "shock spirit," nothing can be achieved.

° ° °

In running down some of the advances which have already been made, Du notes that the hydrogenation of coal tar and medium-pressure gas synthesis for the production of liquid fuels and other chemical products are outstanding achievements in research. And, in the course of the research in the latter projects, catalysts with higher activity have been discovered, with which the yield of hydrocarbons above propane is 191 grams per cubic meter of carbon monoxide and hydrogen. Remarkable advances have also been made in the chromatographic method techniques which are indispensable for petroleum analysis.

With regard to optics and fine mechanics, a series of high-precision instruments has been successfully produced. These include a large electron microscope with a resolving power of 25 Å and magnifying power of 100,000, an automatic-recording infrared spectrograph, a wide-range phase-contrast microscope, a large interferometer, etc. In optics certain conditions leading to the formation of high-order aberrations have been clarified, and as a result the ultra-large aperture $f/0.8$ photo-objective with a viewing field of 40 deg, and the $f/2$ continuously variable focus objective with a maximum viewing field of 60 deg and a focal variation of 1:5 have been successfully designed.

° ° °

Researches in the chemistry and technical use of radioactive isotopes have been set up from nothing. Du tells us they have already succeeded in making more than 30 kinds of isotopes, including phosphorus 32. The techniques in the use of isotopes have already been used extensively in industry, agriculture, medicine, and other scientific and technical fields.

° ° °

The development of semiconductor physics has also been very rapid. Prior to 1956, some research was carried out on semiconductor current rectifiers and semiconductor photosensitive electric resistances. Beginning in 1956, the Chinese started the extraction of germanium and introduced the zone melting purification technique and the making of single crystals. Then they began to use germanium to make alloy-junction medium-frequency triodes, point-contact diodes, gold-bonded diodes, etc. Research on new semiconductors also started at this time.

In the past two years, Du states that, with the assistance of the Soviet Union, "we have successfully carried out the trial making of a universal large-scale high-speed electronic digital computer with a speed of 10,000 operations per sec, three addresses and a storage capacity of 2048 words."

Because of demands made by nuclear technology, electronic computers, multichannel communications, detection and ranging, remote control, and other new techniques, work in radio-electronics, and especially in the fields of electric pulses and microwaves, is rapidly expanding in scope. Research has gone forward on the theory of microwaves and the theory of waveguides, in electron optics and in cathode electronics, and progress has been made in the direction of making microwave measuring instruments, microwave cyclotrons, mass spectrographs, etc.

In physics, the nuclear theory and theories of elementary particles have received attention. "We have im-

(CONTINUED ON PAGE 88)

Chinese Academy of Sciences

In lower left foreground, Wu Yui-hsun, vice-president of the Chinese Academy of Sciences, is rendering a report on "The Life of Benjamin Franklin and his Contribution in Science" to the membership.

COVER: *Microstructure of an AVCO RAD-developed multiphase protective ceramic coating applied to a molybdenum metal heating element and tested to ultimate failure during heating in still air to some 3500 F. Seen in the photo are areas of unaffected molybdenum (gray), as well as molybdenum oxide (yellow) and residual ceramic coating (green). Development of such coatings is part of the AVCO RAD high-temperature materials program.*

Astronautics

JULY 1960

Neighbors Can Be Friends

Nations, like our early colonies, must hang together or they will hang separately. It will not be long before satellites will bind populations together with global radio and television communications. Maintenance of order will be assisted through satellite surveillance. U-2's will become obsolete.

It is fitting that ARS members, who have so much to do with placing such satellites in orbit, begin now to acquaint themselves with what their neighbor nations are doing in space technology. The IAF Congress in Stockholm, August 15–20, presents a good opportunity for members to acquire a more cosmopolitan perspective of the state of the art. This year the papers will be more carefully selected, from a larger number of submitted manuscripts, than ever before. A charter flight which will reduce transportation costs compared to that of a normal transcontinental flight is being arranged.

I urge all who can to attend this meeting and make friends for the United States—friends who may well return the visit next year when the IAF meeting will be held here.

We are all well aware that there is hope for international cooperation and objectivity among independent thinkers trained in the sciences. It is particularly gratifying therefore, to see the establishment of the International Astronautical Academy under the leadership of Dr. Theodore von Karman. The creation of the academy was made possible by a generous grant from the Guggenheim Foundation. It will make its debut at the Stockholm meeting. This body, whose purpose is to honor outstanding workers in astronautics, will have an initial membership of 30 and an ultimate membership of 300. It will provide a stimulus for mutual communication and rapport among men of many nations; men who strongly influence the thinking of their home governments.

In these days when the whole world is looking to the U.S. for proof of character and intelligence, it is important that we of the ARS not behave in a smug or insular way. The quality of the intellectual output of a nation is not necessarily proportional to its size. In the same vein, we should respect the contributions to space technology made by our sister societies in the U.S. We take pride in the fact that ARS is a large and important group in the U.S. space activity, but it is essential that we accord proper value to the contributions of other groups with parallel interests, and that we work toward close cooperation with them.

Our image before the rest of the world should be clear and admirable, not blurred by internal confusion and rivalry.

Howard S. Seifert
President, American Rocket Society

Rocket power—
Key to space supremacy

NASA's new fleet of rocket "trucks" will carry the American standard into space in a broad program of exploration involving 25 to 35 major launchings in each of the next three years

By Maj. Gen. Don R. Ostrander, USAF

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, D.C.

Maj. Gen. Don R. Ostrander was appointed NASA Director of Launch Vehicle Programs on Dec. 16, 1959, on assignment from the Air Force. Previously, Gen. Ostrander was Deputy Director of the Advanced Research Projects Agency. A 1937 graduate of the U.S. Military Academy, he served as ordnance armament officer with the 8th AF Interceptor Command in England during WW II, and later held a variety of administrative posts in the AF Research and Development Command on weapon-system and missile programs. Before joining ARPA, Gen. Ostrander served for a year as assistant to the NATO assistant secretary general for guided-missile production in Paris. He was commissioned a brigadier general in October 1954, and received his second star in March 1958.

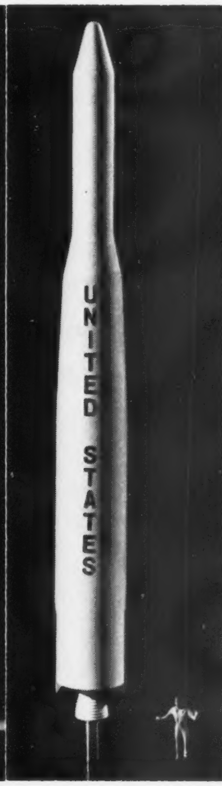
MY SUBJECT is the National Aeronautics and Space Administration's present and planned launching-vehicle program, its scope and pacing; and, by way of introduction, I should like to give some of the philosophy behind this program.

The launch-vehicle program rests on three precepts: (1) To create a standardized fleet of trucks, so to speak, with a minimum number of different types in the fleet. (2) To attain reliability in this fleet by repetitive use of the vehicles. And (3) to avoid early obsolescence in the fleet by incorporating in its vehicles the most advanced technical approaches and growth potential consistent with reliability requirements.

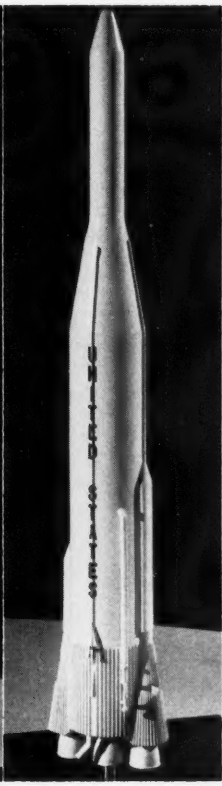
Military's Cooperation Reduces Duplication

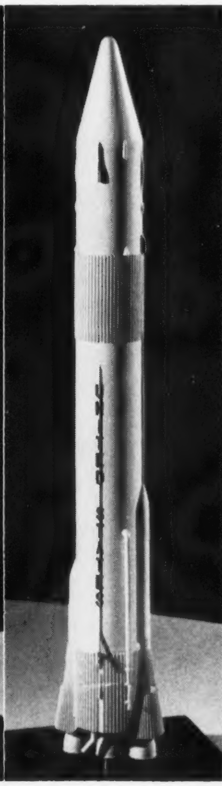
Speaking of the first two of these precepts—minimum variety and repetitive use of standardized vehicles—our objectives here are, of course, economy and reliability. The costs of developing launch vehicles are already high and they are going up in a geometrical progression with each new, larger, and more advanced vehicle that we add to our fleet. The nation cannot, and fortunately need not, afford two major vehicles—one for NASA and one for the military—with approximately the same capability. That is why we are conducting cooperative programs with the military on Scout, Agena-B, and Centaur. That is why, too, we canceled Vega in favor of the Air Force Agena-B. There was nothing inferior about the Vega vehicle. It was just that the Agena-B was a little ahead in time and could do the same job, plus the fact that with a cooperative program we would get more total firings and consequently more reliability.

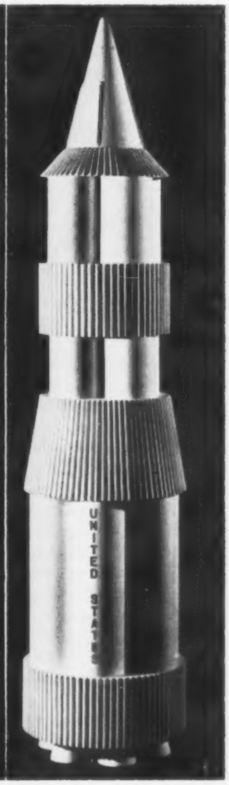
While on the subject of a minimum variety and repetitive use of vehicles, I want to stress that this same philosophy governs the NASA component and technique development programs. We explore various technical approaches methodically and, I think, adequately in our applied-research efforts. But we try to settle on one approach which our analysis shows to be best before we go into full-scale hardware development. An example is our (CONTINUED ON PAGE 89)



JUNO II **SCOUT** **DELTA** **THOR-AGENA B** **ATLAS-ABLE**







MERCURY **ATLAS-AGENA B** **CENTAUR** **SATURN C-1** **NOVA CONCEPT**

The shape of tomorrow

NASA's Ranger project, already in the hardware stage, readies for missions to cislunar space, the lunar surface, and planets Mars and Venus . . . lunar soft-landers and orbiters under design

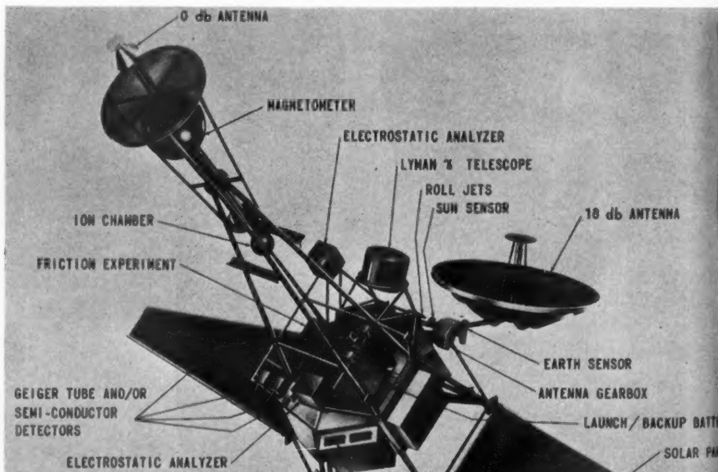
By Clifford I. Cummings

JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIF.

EXAMINE the literature on our moon and the planets Mars and Venus and you will find that we indeed have obtained a great deal of knowledge about them without having left earth. We know their sizes, masses, orbital periods and inclinations, relative distances and velocities, and other basic celestial-mechanic features.

But there obviously is much we do not know. For instance, because we cannot see through the atmosphere of Venus from the earth, we have not yet been able to find out its rotation period or the tilt of its axis of rotation, or even come to a reasonable conclusion regarding its cloud-shrouded interior, whether it has any land masses or is all covered with some liquid.

Clifford I. Cummings is Ranger and Lunar Program Director at JPL. Since receiving a B.S. in physics from CalTech in 1944, he has held a succession of positions with JPL— project leader for WAC Corporal and Corporal missile telemetering systems and range instrumentation, project leader for Corporal guidance, technical coordinator for the complete Corporal system, project director of JPL's portion of the Jupiter program, and head of the systems engineering division. In January 1958, Cummings took leave of absence to join DOD's Weapon Systems Evaluation Group, and then in June of 1958 to become a member of the ARPA staff. In January 1959, he became JPL's representative at NASA headquarters, and then in June 1959 returned to JPL in his present assignment.



Initial Testing Version of Ranger Spacecraft

Also, although we have a great number of facts about our own planet, we still look forward to the information which we are going to obtain from the moon to help us in reaching conclusions about the formation of the earth and the entire solar system.

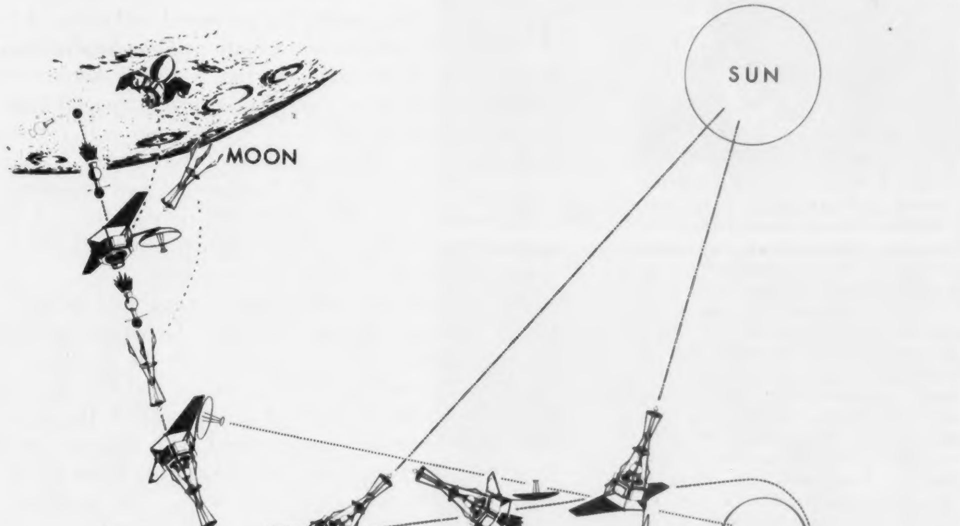
The time has now arrived to start filling in some of the gaps and holes in our knowledge.

We are now faced not with the dreams but with the realities of the space business. We must place in the sequence of potential achievement the missions which will yield the most benefit for the least expenditure of money, time, and talent. We must produce realistic designs within the current state of the art and press advanced development in the appropriate areas so that the new state of the art will be directly applicable to our needs. With infinite patience and care we must fabricate and test our designs and carry out our field operations so that we maximize the reliability of these inherently complex items.

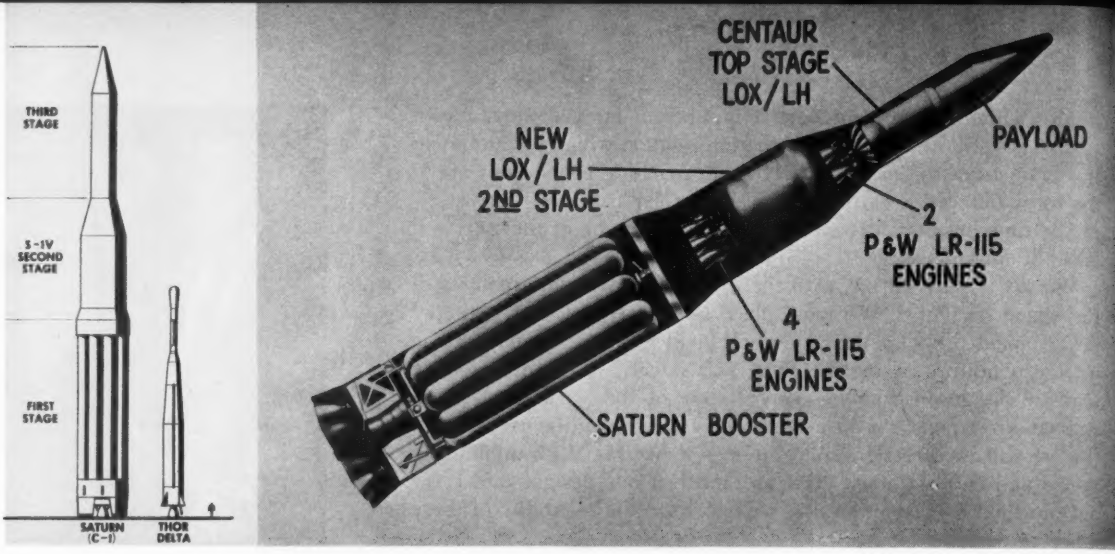
The basic facts of space exploration also provide us with new constraints and requirements concerning the practical approaches which we must use. We are faced with extremely long ranges over which we would like to transmit great quantities of information. We are faced with extreme vacuums. We are faced with types and quantities of radiation about which we are just beginning to learn. For the exploration of the moon and the planets, we are faced with the very new and difficult problem of providing the best possible sterilization of our equipment so that we do not start any life cultures on these bodies which we later would observe and conclude were endemic to that body.

Let me review for you the lunar and planetary spacecraft work which is actually in the design and fabrication stages. At the same time, let me indicate how this work repre- (CONTINUED ON PAGE 91)

The author, left, and Donal B. Duncan, general manager of space technology operations for Aeronutronic, show models of the initial Ranger spacecraft and the lunar-impact capsule it would deliver. Aeronutronic, a Div. of Ford Motor Co., is developing the 300-lb capsule (shown 1/4 scale) for NASA. Notice spherical retrorocket on capsule.



Ranger Midcourse and Terminal Maneuver



THE SATURN C-1

The Saturn project

The giant rockets entailed in this project bid for U.S. pre-eminence in space-payload capability

By William A. Mrazek

NASA MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.

William A. Mrazek has directed the Structures and Mechanics Laboratory of ABMA's Development Operations Div. since 1956, and was instrumental there in the development of the Redstone, Jupiter, Jupiter-C, and Juno II vehicles, as well as the rapid progress on space systems for ARPA and NASA. With the formation of the Marshall Space Flight Center this month, he transfers to NASA, continuing his previous duties under the Development Operations Div. His background includes an MS degree from the Technical Univ., Bruenn, Germany, and development work in the V-2 and Wasserfall projects at Peenemunde during WW II. In 1946, he came to the U.S. as a staff member of the Ordnance Research and Development Div. group at Ft. Bliss, Tex., and later transferred to Redstone Arsenal and ABMA.

THE FIRST of this month, the personnel and many of the facilities of ABMA's Development Operations Div. headed by Wernher von Braun formally transfers to the National Aeronautics and Space Administration as the George C. Marshall Space Flight Center. The major concern of this new NASA team will continue to be the Saturn project. On the occasion of the transfer, it seems appropriate to review Saturn project's background and prospects.

We believe that this project will provide the U.S. with a reliable, economical, all-purpose space-launch vehicle in the $1^1/_2$-million-lb-thrust class at the earliest date practical.

The need for this great booster capability became evident after Russia launched Sputnik I in 1957. Generally speaking, there were two approaches taken to the problem—the development of a single-chamber $1^1/_2$-million-lb-thrust engine and the clustering of a number of lower-thrust powerplants to achieve the same total power. The latter approach was pursued with urgency under the Saturn project because it utilized engines already flight-tested, thus offering high reliability and short lead time. This approach, as expected also proved most economical in terms of facilities, tooling, and hardware. Existing facilities, with some modification, have been adequate for development work.

A brief history of the Saturn project will define this picture in more detail. ABMA conceived the idea of a Juno family of space-launch

vehicles in 1957. Eventually, Juno I launched the Free World's first satellite, Explorer I, and Juno II launched the first U.S. payload into a solar orbit. The Juno III and IV vehicles were not developed, their envisioned missions being assigned to the Able, Delta, Agena, and Centaur series of vehicles. The Juno V design was a high-thrust, clustered-engine booster.

As early as the spring of 1957, ABMA designers were studying the concept of high-thrust boosters using clustered engines. One of the original concepts included the clustering of four Rocketdyne E-1 engines. The E-1 engine, generating about 400,000 lb of thrust, was the largest single engine under development at that time. Preliminary studies of the clustered E-1 looked very promising. In August 1958, the Advanced Research Projects Agency (ARPA) authorized ABMA to proceed with the design and development of a $1^1/_2$-million-lb-thrust booster based on the concept of clustering available engines. The original concept of four clustered E-1 engines was changed to eight clustered H-1 engines, because of the cost involved in completing the E-1 engine development and bringing it to an operational status.

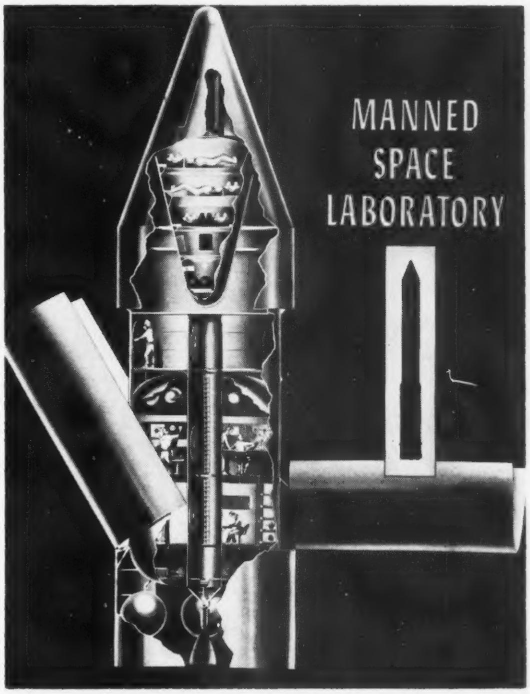
The H-1 engine is an improved version of the S-3D powerplant used in the Jupiter and Thor IRBM's. It was selected because of its relative simplicity, its anticipated early availability, and the backlog of test experience on its ancestors—the S-3, S-4, and X-1 engines. The H-1 engine has an improved packaging concept, a simplified start by use of a solid-propellant turbine spinner and hypergolic ignition, and a simplified lubrication system.

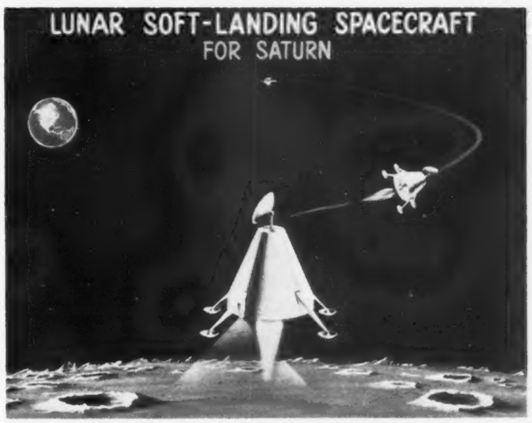
Original Objective Changed

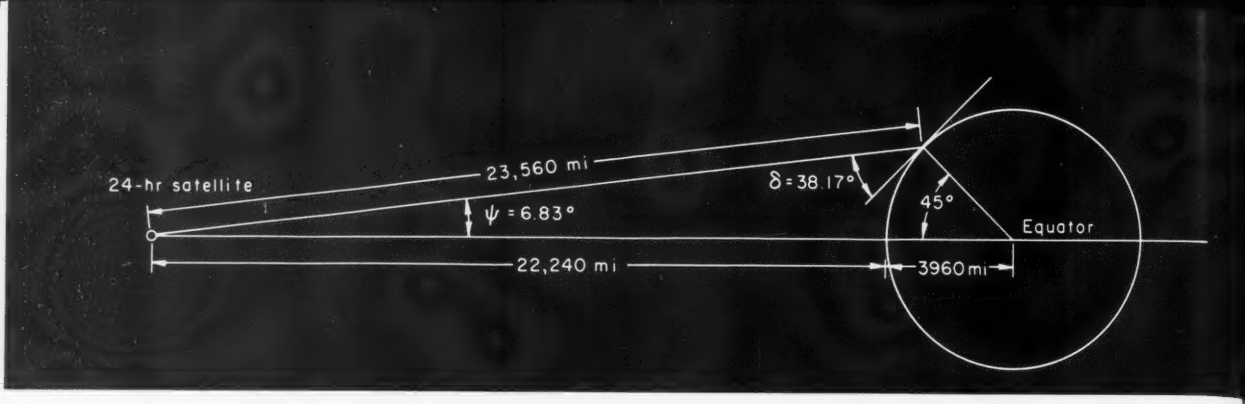
The initial objective of the program was to demonstrate the feasibility of a high-thrust, clustered-engine booster. But in November 1958, ARPA issued a supplemental order changing the objective to the development of a multistage research and and development vehicle. A static-test booster and four flight boosters were authorized. The last two boosters were to use an unsophisticated upper stage (if possible from the shelf) to achieve an early capability for a large orbital payload. Based on the new requirement for a second stage, preliminary studies were made on two-and three-stage configurations using existing IRBM and ICBM hardware. Combinations of this hardware offered reasonable capabilities but did not produce optimum performance.

After several months of experimental studies, in which consideration was given to a Titan booster as a second stage and Centaur as a third stage, work was suspended so that an (CONTINUED ON PAGE 74)

Proposed Saturn Missions







Viewing an Area on Earth at 45-Deg Latitude from the 24-hr Satellite

ASTRONAUTICS Report—Part 3

Observation satellites: Problems and prospects

Video and physical recovery systems for returning data from such satellites, and an analysis of the 24-hr satellite for earth observation

By Amrom H. Katz

THE RAND CORP., SANTA MONICA, CALIF.

There are two distinct ways in which information picked up by a sensor in a satellite can be returned to earth: It can be telemetered back by television techniques, or it can be returned physically in a data capsule. Choice of method will depend upon many factors, among the more important being requirements for timeliness, the rate at which information can be transmitted from satellites, the total volume of information needed, and the form in which the information must be received.

Clearly, certain international inspection operations will require a minimum time delay between observation and transmission of data. An obvious example is a satellite system which observes missile firings, as a part of an international system for early warning of surprise attack. The useful life of such information is a fraction of the flight time of the missiles—a matter of a very few minutes. Other operations may call for a data delay no longer than a very few hours. This would be so, for example, in meteorological or weather observation.

A satellite observation system which gathers data, stores it, and physically ejects it from orbit for subsequent recovery is likely to involve significantly longer time delays, but it may have advantages. The searching and inspection of large areas, or the detailed examination of smaller areas, may result in the collection of such large volumes of data that the transmission capability of the satellite will be saturated. In such a case, physical recovery might well be the better way to get data back.

Mapping is another instance in which physical data recovery is likely to prove better than electronic data transmission. Here the principal concern is geometric fidelity. As noted in another part of this series, geometric precision secured by a suitable system carried in the satellite may be severely degraded in the process of sequential video transmission and reconstitution on the ground.

Accurate judgments should rest on qualitative notions alone, especially when these can be made quantitative. There are as many ways to estimate the information content of a photograph as there are special viewpoints from which to look at it. From the viewpoint of the information-theory expert and the communications engineer, a photograph represents a given and calculable number of bits of information, and this number permits calculation of the required characteristics of the communication channel and the time required to transmit the photograph. It makes little difference, for purposes of the present discussion, whether the photograph is

to be transmitted from a satellite to a station on earth or from one earth station to another.

The photo interpreter tends to evaluate the photograph in terms of the useful detail he can find and the extent of the coverage. The aerial photographic scientist thinks in terms of scale, resolution, and area covered. These several viewpoints are all useful and necessary.

An expression can easily be derived for the information content of a photograph in terms of the number of bits it contains. Let us assume that the photograph has an area of A square inches at an average resolution of R lines/millimeter. The number of photographic line elements in the photograph is then $645\ R^2\ A$.

Expressions for Number of Bits

But, as noted earlier, a photographic line (by convention and usage, and therefore standardized in the field) consists of a line and a space, thus requiring an additional factor of 4 in the measure. Further, the gray scale of a photograph accounts for more bits than would be present if the photograph had only black and white tones. The formula for the number of bits in the photograph thus becomes $2580\ R^2\ A \log_2 G$, where G is the number of discernible gray tones.

Because there is a compression of tonal scale at the higher resolution numbers, and for numerous other reasons involving uncertainty in the meaning of this analysis, it is both difficult and unnecessary to be exact about this formula. Hence, the use of $G = 15$ does not yield appreciable error, especially if the basis of this derivation is kept firmly in mind. The formula for the number of bits then becomes *Number of bits in a photograph* $= 10^4\ R^2\ A$, where R and A are in lines/millimeter and square inches, respectively.

A now classic expression for the number of bits per second which a transmission channel having an effective bandwidth of B cycles/second can deliver is $B \log_2 (1 + S/N)$, where S/N is the ratio of signal power to noise power at the receiver. It must be noted that this is a theoretical upper limit, seldom if ever even approached by real systems. Complicated coding systems (located in the satellite, for the examples of this discussion) must be used. These are not only complicated but costly, sensitive to changes in S/N, and likely to be inappropriate for use in a satellite.

The result of combining theoretical (and unattainable) maximum limits with constraints set by good practice, experience, and reliability is to conclude that a channel having B cycles/second bandwidth can transmit B bits/second—and this too requires that the value of S/N be at least 10 db.

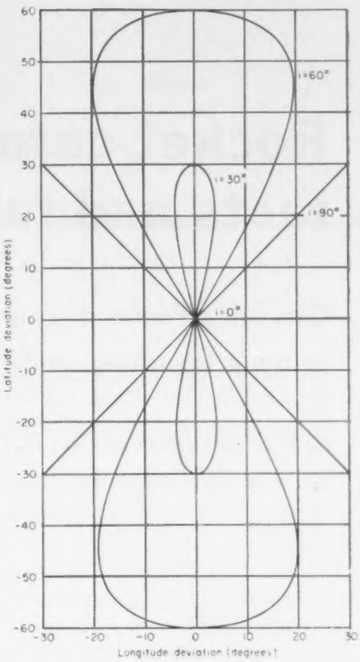
Thus, the time, in seconds, to transmit a photograph of A square inches at R lines/millimeter over a channel with B cycles/second is $t = 10^4\ R^2\ A/B$.

These two expressions—for information content and time to transmit at a given bandwidth—are powerful tools in the analysis and comparison of various systems for securing and transmitting information.

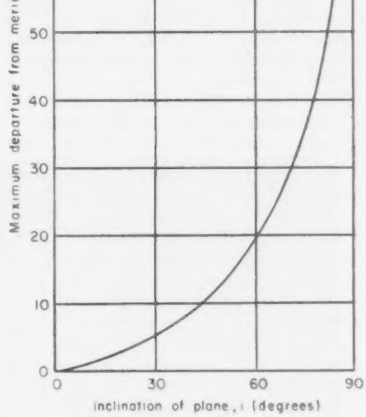
A satellite at an altitude of about 300 miles passing directly over a ground receiving station is in view of that station and can thus communicate with the station—as the satellite appears over one horizon, moves overhead, and disappears below the horizon—for approximately 10 min. Practical limits may be even less than this.

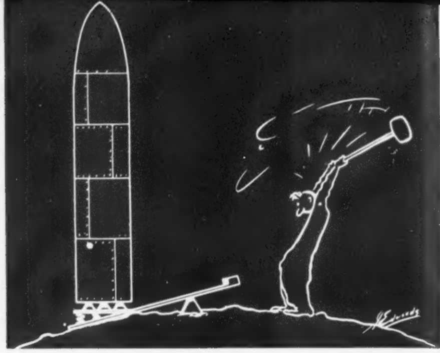
Commercial television utilizes a band- (CONTINUED ON PAGE 80)

Effect of Inclination for the 24-hr Satellite



Maximum Departure from Meridian for Circular Orbit (e=0) for the 24-hr Satellite



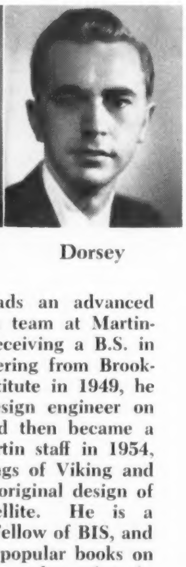


Rocket catapult facts and fables

Catapult schemes are pipe dreams on earth, but the many mechanisms for catapult launching could find extensive use on the moon and like places

By Michael Stoiko and John W. Dorsey

THE MARTIN COMPANY, BALTIMORE, MD.

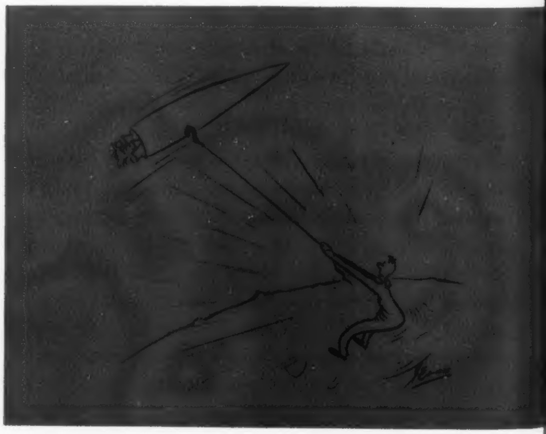
Stoiko **Dorsey**

Michael Stoiko heads an advanced space-vehicle design team at Martin-Baltimore. After receiving a B.S. in aeronautical engineering from Brooklyn Polytechnic Institute in 1949, he joined GE as a design engineer on Project Hermes, and then became a member of the Martin staff in 1954, participating in firings of Viking and contributing to the original design of the Vanguard satellite. He is a member of ARS, a Fellow of BIS, and the author of three popular books on astronautics and a number of technical articles.

John W. Dorsey is doing space-vehicle design analysis in preliminary design at Martin-Baltimore. A contributor to various advanced-design missile and space programs there, his professional background also includes ICBM field-testing and propulsion engineering. He receved a B.S. in mechanical engineering from the Michigan College of Mining and Technology and is a member of ARS.

CATAPULTS have been used to project long-range military missiles for over 3000 years. When man first began to dream and write about traveling to the moon and stars, he adapted the principle of the catapult launch as the obvious means for boosting himself into space.

A classic example was the "cannon-ball" launcher utilized by Jules Verne ("Trip Around the Moon") in 1865. Verne's Columbine launcher was essentially a 900-ft-long cannon mounted vertically in the earth near the present missile site of Cape Canaveral, Fla. His spaceship was a three-man cannonball fabricated from the then rare metal aluminum. The walls of the ball were 1-ft thick. He also resorted to guncotton invented only shortly before. Jules Verne's trajectories were checked mathematically by astronomical experts but his launching technique would have proved disastrous. The initial acceleration of 40,000 g would

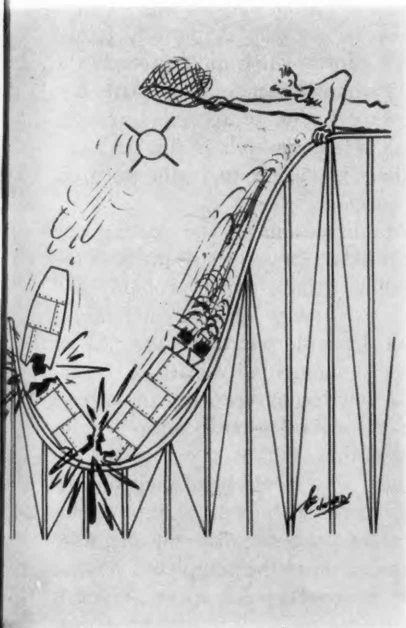


have reduced the occupants to a pulp, and the projectile would have disintegrated under the sudden increased pressure and temperature encountered during launch.

Since Jules Verne's Columbine, many other types of catapult launchers have been proposed—the split tube, the internal-combustion catapult, the coaster, the electromagnetic catapult, the inertial catapult, the ferris wheel, and new versions of the gun barrel.

In modern times, several of the major nations have initiated scientific investigations and actual hardware programs to develop some of these catapult launch techniques. This interest stems from the idea that any incremental velocity contributed to the rocket by a catapult would result in a decreased rocket gross weight. Here's how these catapult devices are purported to operate and why they are really not feasible for the launching of large rockets from the earth.

Split-Tube Catapult: Basically, the split-tube catapult uses steam pressure to drive a piston through a slotted tube. A slide attached to the piston seals the slot behind the moving piston, thus preventing loss of pressure. The launch bridle and guide carrier are connected between the piston and the vehicle being launched —thus the slotted-tube requirement.



Using this launch technique, the German Army during WW II launched the 5000-lb V-1 (Buzz Bomb) missile to 350 fps within 165 ft. After WW II, the U.S. duplicated this weapon system with the catapult-launched Loon. Existing steam catapults have a 248-ft tube and can launch aircraft up to some 80,000 lb at 180 fps. Approximately 1000 to 2000 lb of steam are required per launch.

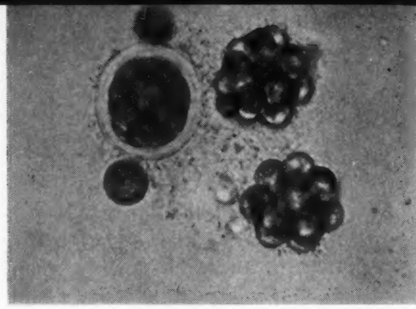
Internal-Combustion Catapult: The new internal-combustion catapult is an improvement over the steam catapult, the difference being primarily the source of energy. A stoichiometric mixture of jet-engine fuel and compressed air is burned and then cooled by water injection. The resulting gases are utilized in the same manner as for the steam catapult. The current internal-combustion catapult capacity is 100,000 lb launched at 210 fps.

In order to launch a Juno-V booster at 1000 fps at a maximum constant launch acceleration of 10 g, a launcher 1500 ft long would be required. (These initial booster launch conditions will be used for all subsequent examples of launch.) The entire system would weigh on the order of 3.5 million pounds, not including the weight of the supporting structure. Output energy for a vertical launch would be 20 billion foot-pounds, requiring 264,000 lb of compressed air, 13,200 lb of JP-5 fuel, and 120,000 lb of water, all consumed within 3.05 sec! Furthermore, the piston-to-rocket connection would have to withstand over 10 million pounds of loading, and the piston and connectors would require a braking system. A water-brake system is the best known to date, but its incorporation into a vertical launcher would impose overwhelming design problems.

Coaster: As an answer to the excessive launching structure and power required for the split tube, we might use a high mountain and a railroad flat car to carry the rocket during launch. This unit coasts down the mountain side, gaining velocity; near the mountain base, the tracks guide the rocket-on-a-car through an upturn to the proper launch angle.

Immediately, the problems of vibration, dynamic loading, propellants acquisition, means of igniting and releasing the rocket, etc. are brought to mind. Very lengthy downhill runs are required to generate sufficient velocity, and the (CONTINUED ON PAGE 93)

Feeding the astronaut



There being no Space Schmoo, the closed ecological system appears a necessity for long-duration spaceflights of the future, and a formidable challenge to the researcher now

By Robert G. Tischer

MISSISSIPPI STATE UNIV., STATE COLLEGE, MISS.

Robert G. Tischer is head of the Microbiology Department and a professor at Mississippi State Univ., where, as well as teaching, he has recently been conducting research on sewage oxidation ponds and spacecrew feeding. After receiving a Ph.D. in food technology from the Univ. of Massachusetts, he taught and did research on food technology, horticulture, and animal husbandry as a professor at Iowa State College. Then, in 1953, Dr. Tischer assumed the directorship of the Quartermaster Food and Container Institute for the Armed Forces Food Laboratory, in immediate charge of its program to develop or improve rations and to investigate radiation sterilization of food. In recent years, his work has centered on the application of statistical methods to research and other problems of food technology. For instance, Dr. Tischer has done notable work in determining the pattern of heat penetration in meats during processing, an extremely important problem. In 1958, Dr. Tischer assumed his present position.

Speculation has produced a host of clever guesses as to how a long-trip feeding system might be partially or entirely closed ecologically; but the basic research efforts which must precede the formulation of any system, and perhaps precede them with discouraging results, have only recently begun to receive increased emphasis. Moreover, there are only a few research groups with any funds for this work, although others are eager to begin research, granted the appropriate financial support.

There are several easily recognizable reasons for the existing rate of progress in space feeding. It is difficult for many to believe in the necessity now for research on feeding systems which probably will not be put to use until a decade or 20 years hence. First things usually being first with the practical people who have the task of building vehicles, they point to the monumentality of their obligation to provide transportation of a reliable nature even for orbital flights of short duration, and observe that food is hardly a top-priority item under the expected conditions of these flights.

On the other hand, only when those who would bend their scientific efforts to closed-cycle-feeding research—biologists, protozoologists, and the like—have made useful progress, may the engineer make his usual and necessary contribution to the completed system. It is therefore necessary to impress those who guide space programs with the urgent and timely necessity for research now if spacemen are to be fed 10 years from now.

Components of Closed System

Let us examine the most probable components of a partly or completely closed system, for some attention to its attributes may serve both to enlighten and impress us.

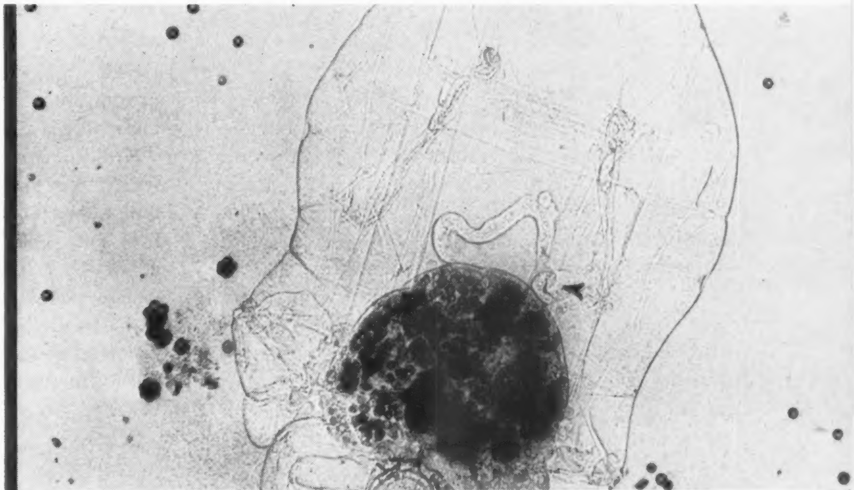
Assume that a closed feeding system will contain a man, some microbes, possibly a plant or two, and one or more animals to complete the necessary conversion of human wastes to usable foods.

Among the microbes which may be desirable in the system, the algae are usually given prominence. This is for the very practical reason that they are expected to return to the system, almost quanti-

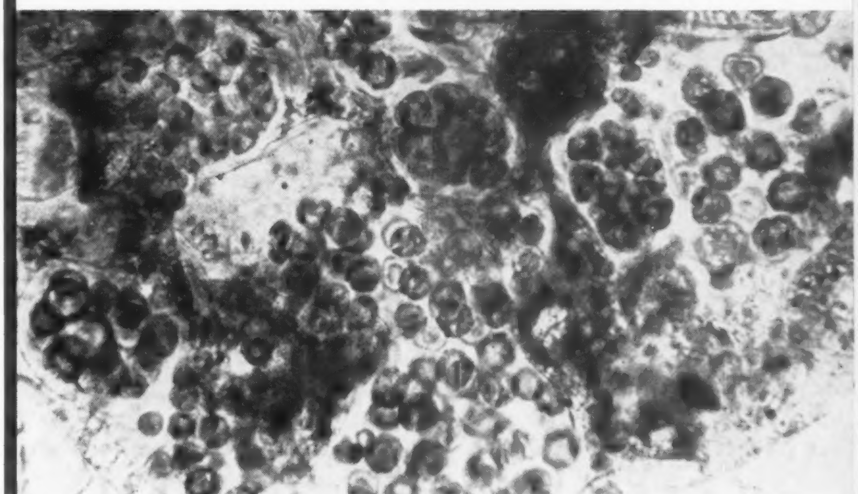
tatively, oxygen for the carbon dioxide exhaled by the astronaut. The experience of scientists to date is almost entirely limited to a few species of *Chlorella*, *Scenedesmus*, and *Euglena*. Of the remainder of the 40,000 algae available to choose from, little or nothing of a functional nature is known. How can they be cultured, how much oxygen will they produce, will mutation or other variation be a problem, can their rates of activity be increased significantly? At present, there are few answers available.

Sorokin and Myers in 1953 isolated a strain of *Chlorella* (now being used by researchers at the Electric Boat Div. of General Dynamics in a closed-cycle, oriented gas-exchange system) which proves to be many times more active than its predecessors. If the vast differences among varieties of these fantastic little plants presage similar differences in their closed-system capabilities, a search through the 40,000 could easily lead to both direct and serendipitous advances. Who is now making this diligent search? Virtually no one.

In the path of elliptical reasoning which characterizes research on closed-cycle systems it is difficult to choose a place to start and a place to end. For lack of a better choice, perhaps the man can be made to serve as the reference. Playing this part, however, he has his faults as well as his advantages. Egocentrically speaking, he is the logical beginning. In practice, however, he will only be a biological converter like the other components of the system, only able to react in a fashion characteristic of the system after one or more cycles have been completed. From this point of view, he is important mainly for the character of (CONTINUED ON PAGE 40)



Microcrustacean containing a full stomach of Pandorina, Eudorina, and Euglena algae.



The same microcrustacean's meal as it appears with further magnification. There is some time lapse before the algae begin to disintegrate.

The silo concept of deploying and restricted-breech launching Minuteman. Automatic equipment will indicate any malfunctioning of the missile and call for a replacement.

Minuteman moves to flight testing

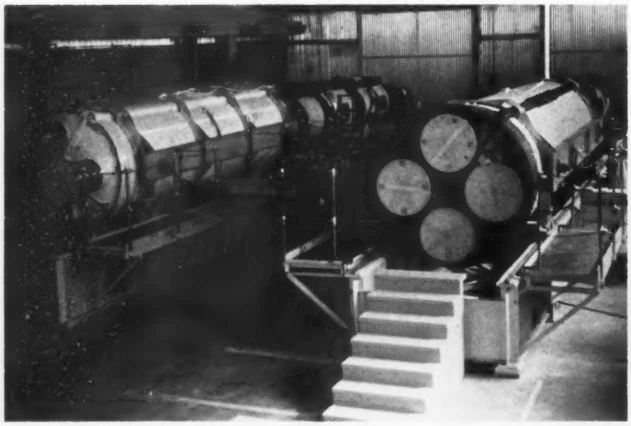
The outstanding success of recent developmental silo-launching tests at Edwards AFB sends this solid rocket ICBM on the road to flight testing at Canaveral in fall

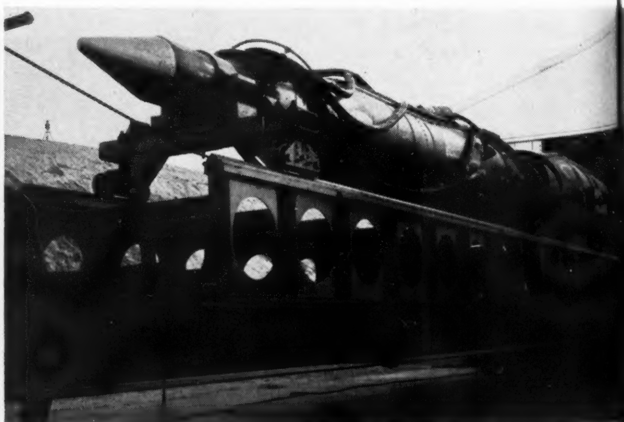
"DEVELOPING the Minuteman missile is now more a straightforward engineering and management operation than a problem of applied research and overcoming basic unknowns," said Col. Samuel C. Phillips (USAF), Minuteman program director, at the conclusion recently of developmental silo-launching tests at Edwards AFB, Calif.

Outstandingly successful, these tests required only eight rather than the planned 18 firings of a full-sized, full-weight dummy missile with just enough propellant in the first stage for a few seconds of propulsion. They confirmed the practicality of silo launching a missile of the Minuteman kind.

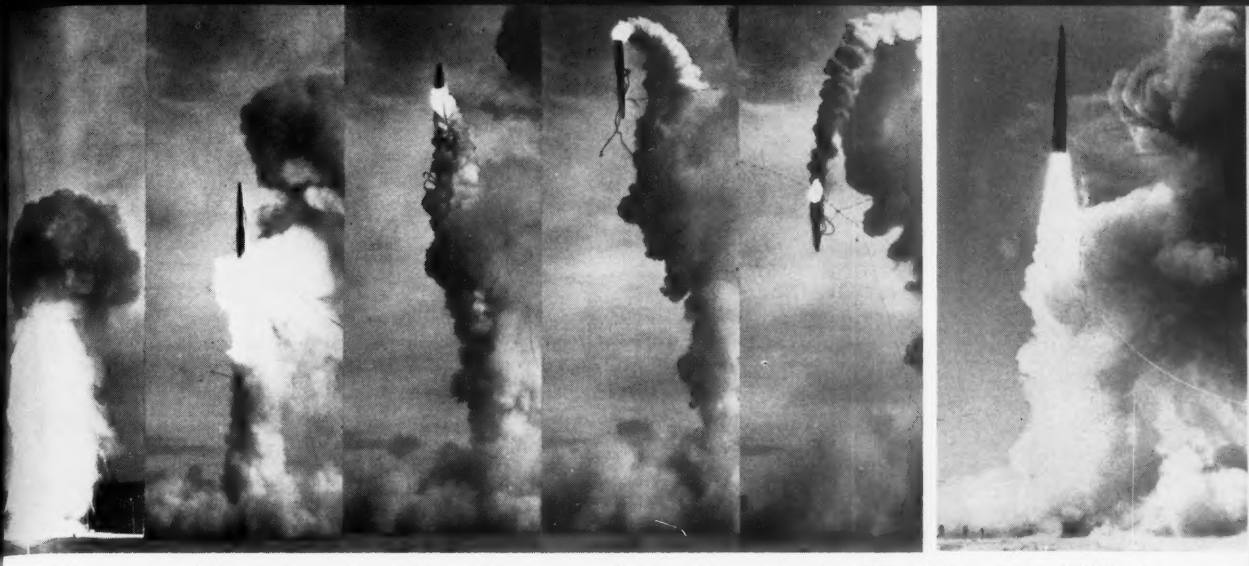
Minuteman now moves to the flight-testing phase, which will be conducted at Cape Canaveral and will begin some time later this year. The missile has been scheduled to achieve initial operational capability in 1962, a year earlier than first predicted.

The prime contractors associated with the Air Force in the Minuteman development program have reported good progress in almost all areas. According to the Air Force, tests of full-scale engines of all





Left, Minuteman test vehicles for silo-launching tests sit in checkout building at Edwards AFB. Right, the full-scale, full-weight test vehicle on its erector-transporter. The top stages and re-entry vehicle are dummies; first stage has some propellant.



This sequence of photos shows, from left to right, a recent silo launch at Edwards AFB, Calif., with a full-sized Minuteman test vehicle. The test vehicle consisted of dummy stages except for enough propellant in the first-stage motor for a few seconds of power during launch. Nylon tethers pull test vehicle toward ground. At right, the peak of the launch.

three stages have been made; the silo tests are complete and lead to flight testing; prototype guidance has been rocket-sled tested; and the prototype re-entry vehicle has been flown on Atlas 5000 miles down the Atlantic Missile Range.

Minuteman will be installed in hardened silos with automatic launching equipment and on trains moving at random over the U.S. railroad network. Tests of rail movement are in progress, and the site for the first three Minuteman squadrons has been picked—near Malmstrom AFB, Montana—and initial construction contracts for these squadron facilities are scheduled to be let in January 1961.

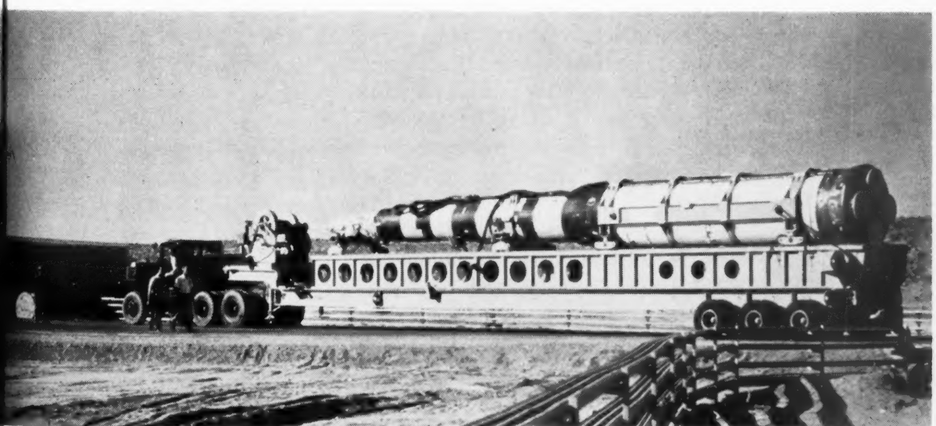
With Minuteman, a circuitous route back to relatively simple long-range artillery with high fire power has been completed. ♦♦

Minuteman Features

Propulsion	Three-stage solid rocket
Speed	Over 15,000 mph max
Range	Over 6300 statute miles
Payload	Nuclear warhead
Launching	Hardened silos and railroad flatcars

Air Force Associate Prime Contractors

Assembly and test	Boeing Airplane
Guidance	Autonetics of NAA
First-stage motor	Thiokol Chemical
Second-stage motor	Aerojet-General (with backup by Thiokol)
Third-stage motor	Aerojet and Hercules Powder in parallel developments
Re-entry vehicle	Avco



Left, the test vehicle on its transporter moves to a silo. The simplicity of handling Minuteman is striking. Right, a crane lifts the missile from the erected transporter bed and prepares to lower it into the silo.

Radiation danger in space

Nuclear emulsions recovered from a Thor-Able nose cone convey the first data on the dosage field for a man traversing the Great Radiation Belt

By Hermann J. Schaefer

U.S. NAVAL SCHOOL OF AVIATION MEDICINE, PENSACOLA, FLA.

Hermann J. Schaefer is head of the Biophysics Department of the U.S. Naval School of Aviation Medicine. He received a Ph.D. in physics and biophysics from Johann Wolfgang Goethe Univ. in Frankfurt am Main, Germany, in 1929, and before coming to his country in 1948, was professor of biophysics at that university. Dr. Schaefer is engaged in research on the biological significance of background ionization and radiation in space.

Van Allen's discovery of a belt of high-intensity ionizing radiation girdling earth at extreme altitudes in the equatorial region has brought a revolution in our concepts of radiation hazards in spaceflight. In the pre-satellite era it was generally believed that radiation effects on man in extra-atmospheric and space flight would be essentially limited to "microbeams" of heavy nuclei and narrow meson cones. As to destruction of living tissue, the general consensus was that damage, while negligible for short exposures, would develop slowly and inconspicuously during extended exposures. It was thought that this damage would be similar to that from so-called low-dosage long-term irradiation, and would manifest itself in such unspecific effects as shortening of mean lifespan and increased mean incidence rate of malignancy, both of which are identifiable only statistically. These assumptions are no longer tenable in the light of new information. There is little doubt now that, at least in certain regions of cislunar space, ionization dosage reaches a level that can cause acute radiation injury.

Basic Facts on Van Allen Belt

The basic facts on spatial configuration and particle intensities of the Van Allen belt have been presented repeatedly. For a brief summary, it can be stated that, beginning at about 1000-km altitude, the intensity of the ordinary cosmic-ray beam exhibits a sudden steep increase, doubling its value about every 100 km. At 3000 km a first, and at 15,000 km, a second maximum is passed. The two zones cover different latitude ranges: The first one extending from about 20 deg N to 20 deg S and the second one from 50 deg N to 50 deg S. Strong experimental evidence indicates that the first zone, consisting mainly of high-energy protons, will pose a much more exposure hazard because of the high penetrating power of a large fraction of the proton beam.

Although the recordings of the Explorer satellites and Pioneer probes furnish the full-altitude profile of the particle intensity in both belts and far beyond along their respective trajectories, they do not convey conclusive information on the total ionization. How large a margin of uncertainty this leaves with regard to actual tissue ionization dosages becomes evident if one realizes that a high-energy proton produces as few as 5 ion pairs per (CONTINUED ON PAGE 42)

An interior view of an ammonia-maser clock being developed for NASA by its inventor, Harold Lyons, at Hughes Research Laboratory. The clock will weigh about 30 lb.

Atomic clocks for space experiments

Possible uses suggested range from an experimental check of the General Theory of Relativity to various communication and tracking applications

By Peter L. Bender

NATIONAL BUREAU OF STANDARDS, WASHINGTON, D.C.

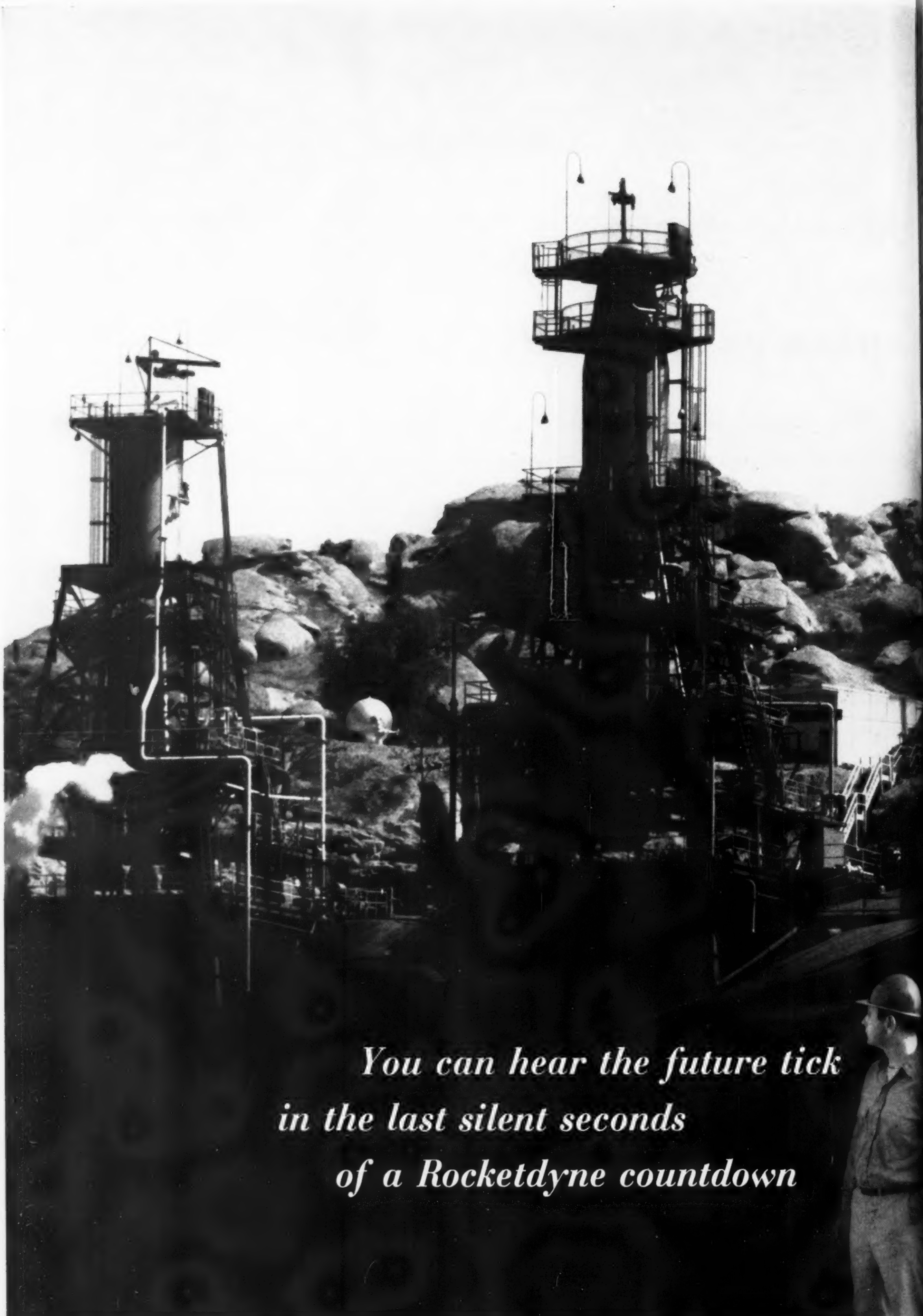
Peter L. Bender, a physicist of the NBS Atomic Physics Section, was graduated from Rutgers Univ. in 1951, and, after spending a year at Leiden Univ. on a Fulbright grant, studied at Princeton Univ., where he received a Ph.D. in physics and an M.A. in mathematics. In 1956, he came to the Bureau of Standards as a National Research Council postdoctoral fellow. Dr. Bender received an Exceptional Service Award from the Department of Commerce in 1959 for work on the proton gyromagnetic ratio and on hyperfine spectroscopy.

RECENTLY a number of possible uses of atomic frequency standards in satellite and space-probe vehicles have been suggested. They range from an experimental check of the General Theory of Relativity to communications and tracking applications. Of immediate interest are the capabilities of present atomic standards and of quartz-crystal oscillators for some of these purposes. In some cases what is needed is actually a clock rather than a frequency standard, but this can be easily obtained by feeding the frequency standard output into a counter.

The varieties of atomic frequency standards which have been suggested for space-vehicle use are the cesium-beam, rubidium-vapor, and ammonia-maser types. In each type, the clock rate is determined by a quartz-crystal oscillator whose frequency is servoed to the chosen atomic or molecular transition. In the first two types the oscillator frequency is continuously adjusted so that an even multiple of it will cause internal transitions in the atoms being used as a reference. For the cesium beam, these transitions cause small deflections of the paths of the atoms, while for rubidium vapor the internal transitions cause changes in the optical absorption coefficient of the sample. The ammonia maser differs from the other two types in that the ammonia molecules emit radiation which is used directly to control the oscillator frequency.

The cesium-beam frequency standard is at present the most advanced of the three types. Such standards are now available commercially with an accuracy of about 2 parts in 10^{10} and a day-to-day stability of a few parts in 10^{11}. An improved version of the apparatus is expected to be available soon. However, this apparatus is about 6 ft long and is not particularly suitable for space-vehicle use. Shorter versions, which will be less than half as long, are under development, with an expected stability of about 1 part in 10^{10}.

Commercial television utilizes a band- (CONTINUED ON PAGE 80)



You can hear the future tick
in the last silent seconds
of a Rocketdyne countdown

Feeding the Astronaut

(CONTINUED FROM PAGE 33)

his wastes, the variety of his demands for energy, and the performance he can synthesize from it.

It is indeed unfortunate that it is so difficult to design a waste-conversion system which can only continue to function if the man returns to it a form of waste which can continue in use by the remaining biological units necessary to complete the cycle repeatedly.

Stated more simply, every biological component of the system requires a set of chemicals which it considers to be food and each produces a type of waste peculiar to its metabolic pattern and to its diet. Moreover, the wastes from one are readily usable as food by the next if, and only if, the sequence is fortunately chosen.

What Is Known

Observation of the flora and fauna of any sewage-treatment operation quickly proves that human wastes support the growth of bacteria, yeasts, molds, protozoa, algae, worms, and even frogs and turtles.

Yet, in spite of the large effort directed toward an understanding of sewage stabilization, very little of an exact nature is known about the specific composition of human wastes in terms of ability to support the continued growth of microplants and animals. We can only say that many types of microbes will grow on human wastes. We know nothing of which types will most often predominate in a closed cycle or whether the ones that do can be counted upon to provide the very necessary biochemical conversions to allow continued nutrition for the bio-unit next in line.

Which is to say, that from both a biochemical and a microbiological point of view, the research leading to a successful closed feeding cycle is nothing less than a scientific morass.

Experiments are now beginning which will tell us whether human wastes resulting from controlled diets differ from one diet to another in their ability to grow algae and other micro-organisms. We already know from recent work that human feces in concentrations ranging from one to almost 100 percent will support the growth of algae. Examples of algae which will grow under these conditions are *Chlorella, Ankistrodesmus, Palmellococcus, Chlamydomonas*, and *Actinastrum*. All of these will convert a part of the human wastes into oxygen and algal protoplasm, leaving behind a complex mixture of nutrients which must all be put to use in the cycle.

We can postulate a chain of food conversion something like this. The task of using the remaining nutrients may well fall to the bacteria, while the harvesting of bacteria can be done by many types of protozoa. They might be followed by microcrustaceans (water fleas) such as the *Daphnia, Moina*, and *Polyphemus*, which have a voracious appetite for algae and often harvest substantially all of the algae from a large pond in the course of a few hours. The photos on page 33 show a microcrustacean which has eaten a micromeal of algae, and a further magnified view of the already eaten algae, still inside the water flea. The latter photo shows that the algae, which are quite durable little plants, have not yet been dissolved by digestive processes; the fleas, for a time, make a handy package of collected algae.

Then, in one more biological step it is possible to convert the water fleas into fish, since many small varieties of fish subsist partly or entirely on algae and will eat the fleas.

Adopting the rigorous point of view of those who believe spacemen can be conditioned to simple diets, this chain of conversions provides human food of sorts, albeit leaving much to be desired in the way of variety, texture, and flavor.

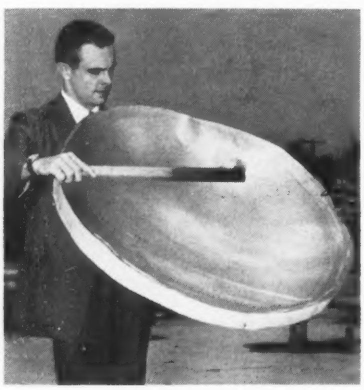
Penalty Paid

Further steps toward a more appealing diet can, of course, be made. These added advantages cannot be obtained without high costs. Each new step adds undesirable complexity, bulk, and failure probability to the system. The energy requirements of the system will increase, and the various inefficiencies will add up to produce a very wasteful, slow, and cumbersome system which describes quite well that found in nature. Those who have the gourmet's stance regarding spaceflight meals are in favor of the inclusion of large animals for production of familiar meats and for the hydroponic production of vegetables. The goat has been a favorite suggestion as a meat producer, probably because he has a reputation for unfastidious eating. A goat, however, weighs about 100 lb, of which only about 30 lb are edible. While the goat could probably control the amount of cellulose in a feeding cycle, he would, when eaten, produce about 70 lb of very troublesome waste products in the form of entrails, hair, hoofs, and horns.

What seems to be needed is a dwarf ruminant, probably the size of a cat, which has no hoof, claws, hair, horns, etc.— in fact, which can be eaten in its entirety. Reasoning in this fashion brings us back to the small fish, or possibly to the snail or the slug, as the main item of diet.

No one would spend very much time attempting to develop a closed biological system for long spaceflights unless there were no other alternative. Since there appears to be no really promising alternatives [*Ed. Note—For a contrasting opinion, see December 1959* Astronautics, *page* 52], much careful basic and applied research is needed on photosynthesis, gas exchange, cellulose control, compatible mixed culture techniques, evaluation of simple diet vs. performance, and systems propagation. ♦♦

Hot Work with Solar Concentrators



Engineer Don McClelland watches a stick start to smoke in a fraction of a second as he places it at the focal point of one of the lightweight (this one 2 lb) solar concentrators being developed and evaluated by Electro-Optical Systems.

Solar concentrators that weigh less than 0.3 lb per sq ft and give nearly 90-percent concentration efficiency have been developed by the Energy Research Div. of Electro-Optical Systems Inc., according to its manager, James H. Fisher, and he expects even lower weights and higher efficiencies in the near future.

Concentrators in the form of a paraboloid of revolution or a Fresnel mirror have been made by EOS in both rigid-deployable and nonrigid designs, utilizing aluminum, beryllium, and nickel for surfaces and Mylar and hard foams for backing. Fabrication techniques have included explosive, electro, stretch, and Andro forming.

Experimental solar concentrators fabricated by EOS and currently under evaluation are approximately 3 ft in diam, but this size will be increased to the 5- to 10-ft range in the near future, according to Fisher.

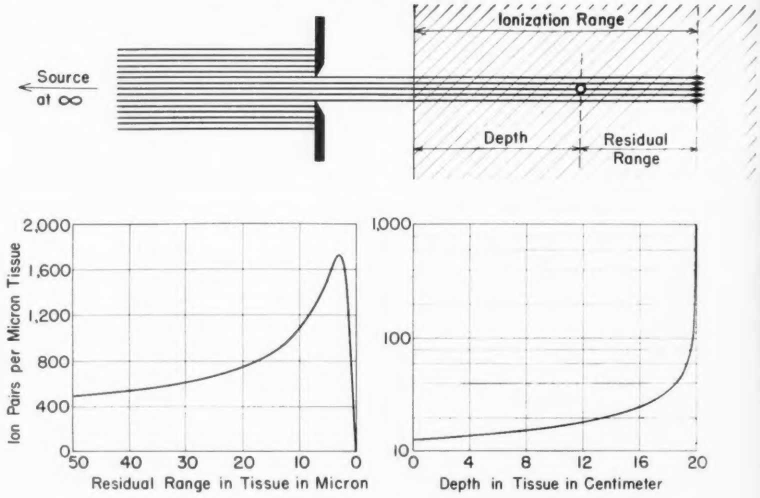
(CONTINUED FROM PAGE 36)

micron tissue and that a low-energy proton produces as many as 1730.

The first break in this deadlock occurred recently through the measurements of Freden and White of the Lawrence Radiation Laboratory, Livermore, Calif. They succeeded in recovering a nuclear emulsion package from the nose cone of a Thor-Able missile which flew through the lower fringes of the Van Allen belt. The missile spent 15 min beyond 1000-km altitude between 20 and 3 deg N latitude and reached a peak altitude of 1230-km. Although this is not much more than just a thin surface layer of the Van Allen belt, the recordings open a way of determining, for the first time, the actual tissue ionization dosage and depth dose pattern in a biological target.

A brief recapitulation of the mechanism of proton attenuation in an absorbing medium will help in evaluating the significance of the Freden and White experiment. The graphs at the right show the so-called Bragg Curve for protons. A parallel pencil beam of monoenergetic protons is visualized penetrating living tissue. The plot demonstrates the well-known fact that the REL (rate of energy loss) as the beam enters the absorber, starts off with a comparatively small value and increases, first slowly and finally precipitously, as the particle speed decreases. Shortly before the kinetic energy of the particles is completely spent, the REL passes through a steep maximum of 1730 I.P. per micron. In the lower righthand graph, this terminal section of the beam is not indicated because the ordinate and abscissa scales have insufficient range and resolution. This section, therefore, is plotted separately in the left graph. Since the number of ion pairs per unit mass of tissue directly determines the dose in roentgens equivalent physical (REP), a beam of monoenergetic protons produces a highly structured dose pattern in tissue, with a focal spot of high intensity at a certain depth depending on the entrance energy of the protons. It is essential to realize that this characteristic depth-dose pattern holds only for a monoenergetic beam, i.e. for a bundle in which all protons have the same kinetic energy. If a mixture of different energies is present, a number of focal spots at different depths within the target will develop, and the resulting depth-dose curve will depend greatly on these different energies and the respective particle frequencies.

Bragg Curve for Protons in Tissue



Terminal section of beam is shown separately at higher resolution in left graph.

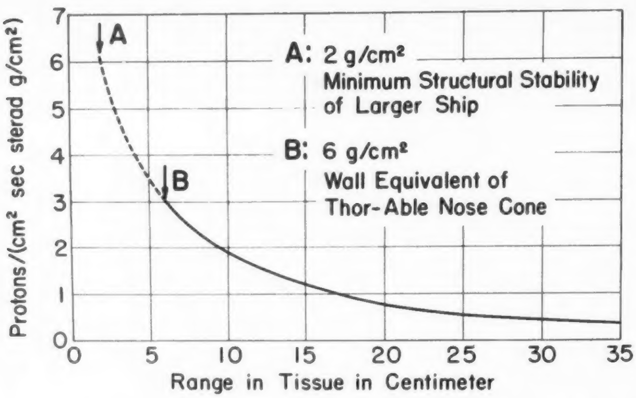
The graph at left shows the energy spectrum for the proton beam in the Van Allen belt as it follows from the measurements of Freden and White. If it is to be evaluated in terms of the depth-dose curve in a compact target, such as the human body, the computational procedure is greatly simplified if the differential energy spectrum is converted into the differential range spectrum. This conversion is a routine operation involving three computational steps. Integration of the differential energy spectrum furnishes the integral energy spectrum, which in turn can easily be converted into the integral range spectrum. Differentiation of the latter, finally, leads to the differential range spectrum shown by the graph on page 44.

At this point, the question of the low-energy end has to be discussed. The experimental design of Freden and White was such that the radiation had to penetrate 5 g/cm² wall material of the nose cone and an additional 1 g/cm² of emulsion casing. Penetration of these 6 g/cm² absorber thickness requires, for protons, a minimum

Differential Energy Spectrum of Protons in Inner Van Allen Belt

Actual measurements cover only energy interval from 80 mev up. Broken section of curve down to 45 mev is extrapolated using the exponential function of best fit suggested by Freden and White. (S. C. Freden and R. S. White, "Protons in the Earth's Magnetic Field"; *Physical Review Letters*, vol. 3, no. 1, July 1, 1959, pp. 9–11.)

Differential Range Spectrum of Protons in Inner Van Allen Belt



For explanation of broken section of curve, see graph on page 42; the 6 g/cm^2 wall equivalent of nose cone consists of 5 g/cm^2 nose-cone wall and 1 g/cm^2 emulsion casing.

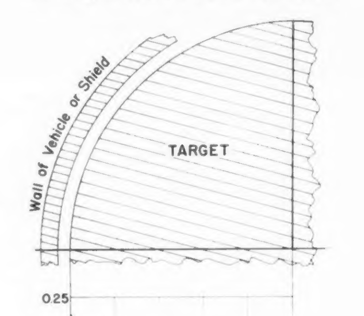
energy of 80 mev. On the other hand, if the special requirements for heat protection during re-entry are disregarded, it seems a reasonable estimate that structural stability of a larger man-carrying vehicle in free space would not demand more than about 2 g/cm^2 of wall material. For a realistic appraisal of the radiation hazards, then, the intensity should be known for the additional spectral section from 6 to 2 g/cm^2 penetrating power, corresponding to energies from 80 to 45 mev. The Freden and White experiment does not give data on this range.

Since the data of Van Allen, as well as general theoretical reasons, strongly indicate that the steep intensity increase toward lower energies continues well below the 45 mev level, the liberty has been taken in the following analysis to extrapolate the data of Freden and White, using their empirical exponential formula for the energy spectrum in question. The extrapolated section is indicated in the bottom graph on page 42 and the graph above by the broken lines.

If the heterogeneous proton beam represented in the graph shown above penetrates a compact target, such as a tissue phantom, low-range components are constantly being eliminated by absorption, and this process causes a continuous change in the spectral composition of the beam. It is a somewhat time-consuming yet basically simple procedure to break down the entire range spectrum, as shown in the graph above here, into small sections and to plot or tabulate for each section its individual Bragg Curve. By superposition of all contributions, point for point for each depth in the phantom, the total ionization at each point—i.e., the local dose rate in r/hr—can be established.

The results of such a numerical integration for a spherical tissue phantom of 52-cm diam (corresponding to 75-kg weight) surrounded by a concentric shield are depicted in the graph below here for several thicknesses of shielding. It can be seen that the essential feature of the Bragg Curve for a monoenergetic proton beam—namely, the steep maximum at a finite depth, as shown in the graphs on page 42—has entirely disappeared. As ionization peaks are spaced all over the full depth of the target, beginning from the very surface, and as the total number of protons constantly decreases with

Depth Dose Along Central Diameter in a Spherical Tissue Phantom



Note steep drop of dose rate in first few centimeters for low shielding.

increasing depth, due to the gradual elimination of components of lower energy (range), the resultant ionization density (the tissue dosage) shows a monotonic decline with increasing depth.

The depth-dose curves in the graph below suggest that the steepness of decline of the local ionization dosage is greater in the initial layers of the target sphere and for lower pre-filtration in the shield. This finding is to be expected from general reasoning. Since fractions of low penetration are extinguished first in the beam, the penetrating power will grow toward deeper regions in the absorber. This phenomenon—that a heterogeneous radiation changes its spectral composition on its way through an absorbing medium—is quite common. It is particularly well known and well investigated in medical radiation dosimetry. The classical case is the hardening of an X-ray beam in the process of absorption. For a quantitative description, the half value layer (HVL) is usually referred to. The lower graph on page 45 shows the HVL in lead for 250-kv X-rays as a function of depth in the irradiated object. The HVL undergoes a considerable change in the initial layers and then levels off to a constant value.

In contrast, the HVL of the proton beam in the Van Allen belt does not show any indication of a leveling off, as can be seen in the upper graph on page 45. Starting off from the value of 4.5 g/cm^2 behind a filter of 2 g/cm^2, it increases rectilinearly through the full range of tissue depths that would be of interest in a target the size of the human body.

Owing to this peculiar fact—that the proton beam in the Van Allen belt never achieves homogeneity, even for very heavy pre-filtration—the radiation load for a given target depends very sensitively on the nature of the individual target, such as size and shape (e.g., body position). By inspecting the curves at left, it can readily be seen how strongly the steepness of decline of dose rate depends on pre-filtration, whether the latter is afforded by an actual radiation shield or by outer layers of the human body itself. In fact, it seems almost impossible under these circumstances to give a total body radiation burden realistically as a concrete, general figure.

At first sight, the highest dose rate of 0.23 REP/hr (shown in graph at left as the target entrance exposure for minimum pre-filtration) appears quite moderate. It has to be realized, however, that it represents the radiation intensity in the outer fringes of the radiation belt, where the dose rate is considerably below its maximum. It is tempting to extrapolate this dose rate at 1230-km altitude to

the maximum at 3000 km by using Van Allen's full-altitude profile of the particle intensity. Unfortunately, such an extrapolation can be based, at present, only on the assumption that the spectral composition of the radiation dose does not change across the radiation belt, since no data on the transition of the energy spectrum are available. This proposition, however, stands on shaky grounds inasmuch as the basic mechanism of particle trapping in the magnetic field of the earth, which is responsible for the high radiation intensity, postulates that at different distances from the magnetic dipole, i.e., at different altitudes, different particle energies fulfill the conditions for stable trapping.

Keeping these reservations well in mind, we would have to base the estimate on Van Allen's finding that: "The intensity increases in the region 1000 to 2200 km by approximately a factor of two per hundred kilometers." This leads to a factor of about 500 for the intensity at 2200 km as compared to 1230 km. Applied to the intensity of 0.23 REP/hr at 1230 km, this yields a dose rate of about 120 REP/hr at 2200 km. Yet it should be emphasized that this value represents an order of magnitude rather than a precise figure of the maximum intensity, for the reasons we have discussed.

In view of the provisional character of present information, a detailed discussion of its implications for the design of shielding seems premature. But two general questions may be briefly mentioned.

First, the attenuation of protons in aluminum as compared to tissue is of interest in estimating shielding weight. In the energy range between 45 and 800 mev, the absorptive power of aluminum is only about 12.5 percent smaller than that of tissue for the same total weight. It also should be mentioned that high-energy protons are not only attenuated by ordinary ionization, but also by a number of nuclear interactions. However, the resulting mean free path for these events is, for the energy range in question, about 120 g/cm^2 in air or tissue. This contribution to the total attenuation, therefore, can be safely disregarded for targets of the size described by the graph at the bottom of page 44.

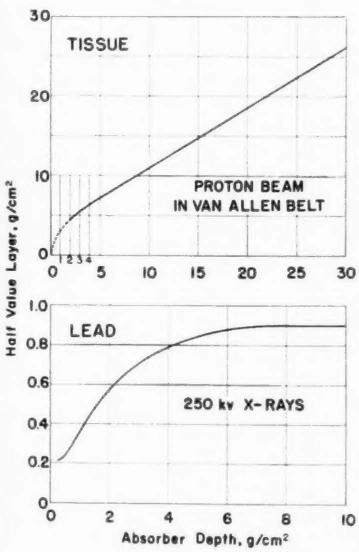
Finally, the radiobiological question of the RBE (relative biological effectiveness) for protons is likely to be brought up. Densely ionizing particles, such as protons, are known to inflict, for the same dose in REP, greater damage upon living matter than X-rays or gamma rays. The RBE of such corpuscular radiations is greater than one. The RBE depends, though in a very complex fashion, on the REL and will be significantly larger than one only for REL values greatly exceeding 200 ion pairs/micron tissue. By consulting the graphs on page 42 and 44, it is seen at once that only a negligible fraction of the total energy dissipation is produced at an REL exceeding 200 i.p. per micron. The mean RBE of the proton beam in the Van Allen belt, therefore, remains very close to unity.

The radiobiologist in particular should be aware of this fact, since he might be inclined to compare the case in question to the dosage field or recoil protons in an absorber exposed to neutron bombardment, as this latter case is the only one for natural or artificial terrestrial radiation sources in which heavily heterogeneous proton radiation fields are encountered. The proton field in the Van Allen belt in no way resembles these neutron-produced fields.

On the other hand, this reassuring aspect of RBE should not create a false sense of security. Close attention must be paid, in particular, to the eyes of a human target, since the lenses of the eyes will be exposed to the full body entrance dose, and will show a considerably greater radiation sensitivity than the skin to permanent, progressing injury (e.g., cataract formation).

Here again, a fruitful debate would require more specific information on the intratarget dosage field and its transition on a traversal of the Great Radiation Belt. ♦♦

Half-Value Layer as a Function of Depth



Lower graph shows, for the purpose of comparison, the type of HVL curve commonly found in heterogeneous radiations. Note complete absence of saturation effect and much larger ordinate scale for proton beam in inner Van Allen belt, as shown in top graph.

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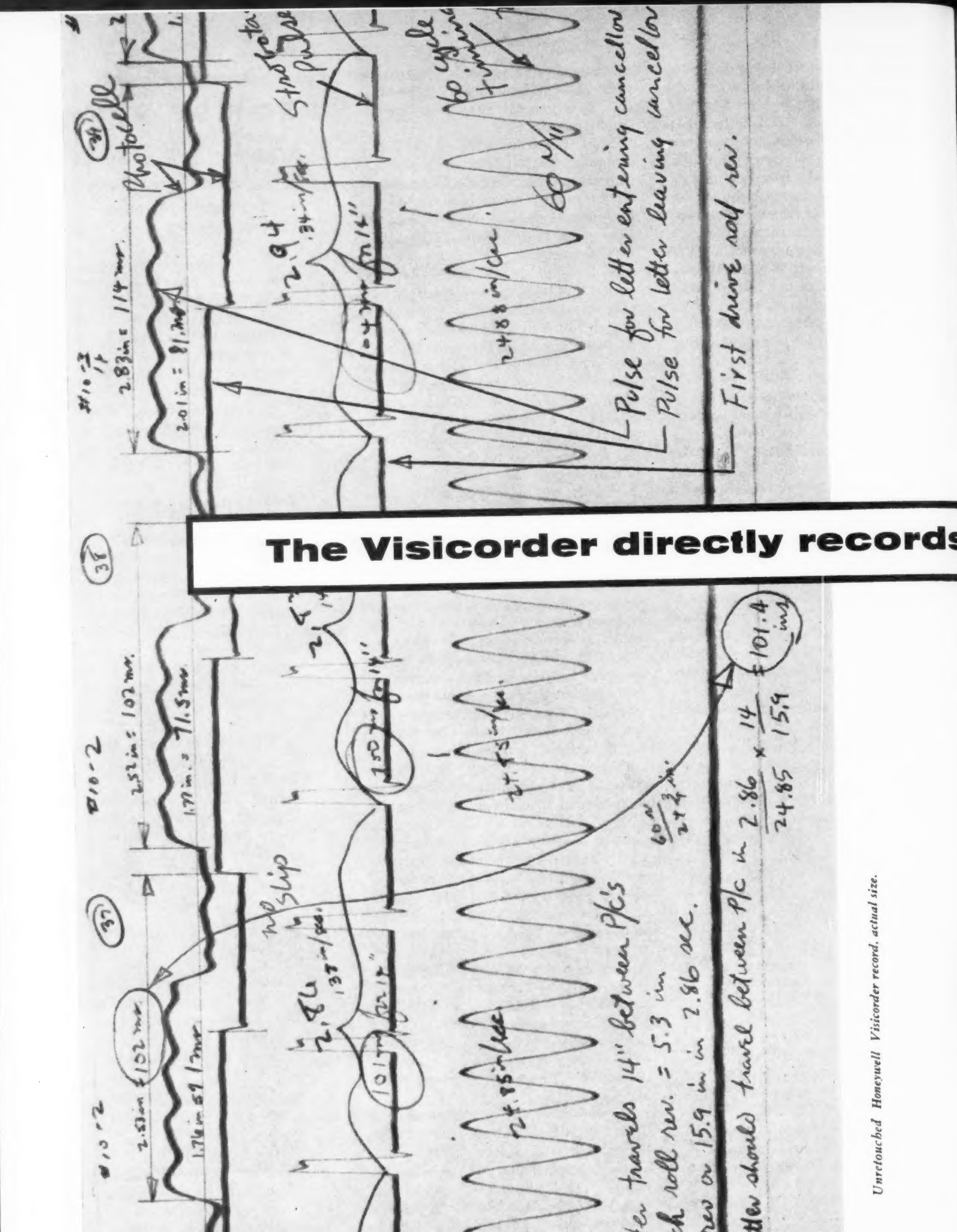


Unretouched Honeywell Visicorder record, actual size.

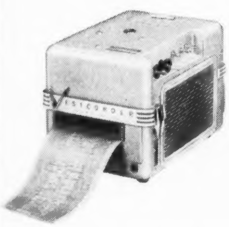
The Emerson Research Laboratories at Washington, D.C., directly-recorded this chart on a Honeywell Model 906 Visicorder. The chart shows a canceller test of a number of letters through a new mail-handling machine developed by Emerson for the U.S. Post Office Department.

In this test, the Visicorder took only 3 hours to reveal information that would have taken 3 weeks to get by any other means: what factors were responsible for the changing speeds of letters as they traveled through the machine at the rate of 30,000 letters per hour. Constant letter-travel speeds were necessary in order to register the cancellation mark on the stamp every time.

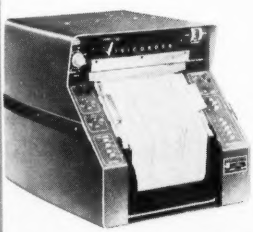
This Visicorder record revealed that motor speed variations, belt slippage and slippage of the letter in the drive rollers were responsible. A synchronous drive motor, a timing belt drive and a better grade of rubber in the drive rollers were added to solve the problem—at a vast saving in engineering time.

Milton Stovall, Emerson Project Engineer, uses the Visicorder to measure roller bounce caused by various letter thicknesses, and the consistency of letter speed through the new Emerson Automatic Mail Cancelling and Facing Machine.

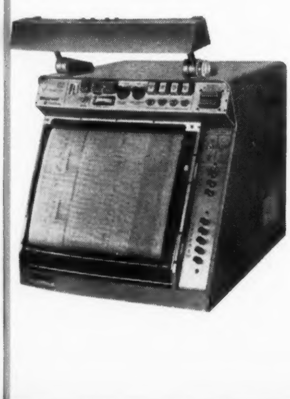
high-speed letter travel



Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.



The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

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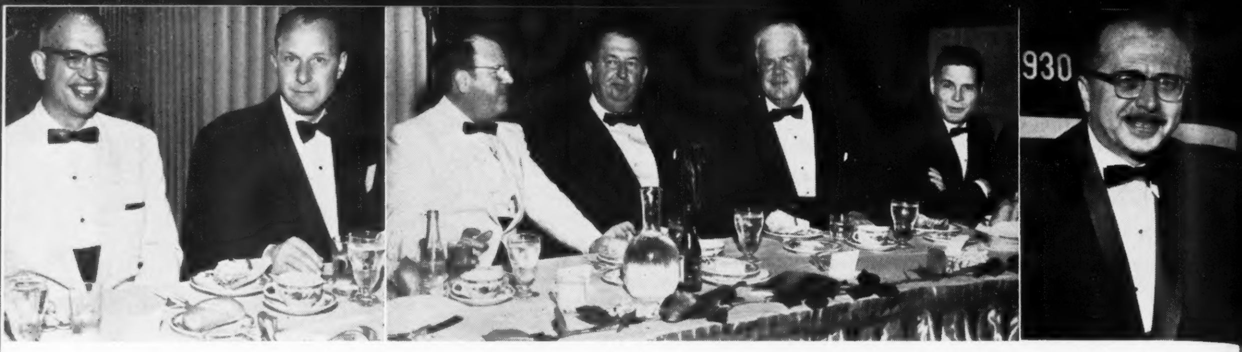


Semi-annual meeting in Los Angeles draws attendance of 4000

By Irwin Hersey

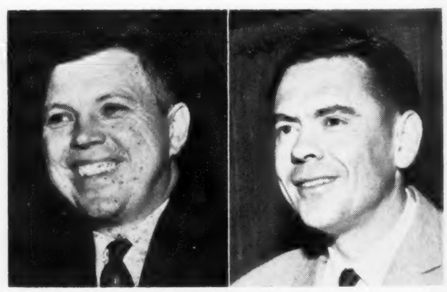
Los Angeles, Calif.—An outstanding technical program, what was acknowledged to be the finest Astronautical Exposition ever held on the West Coast, the ARS 30th Anniversary Commemorative Banquet, four stimulating addresses, and several other attractions, all coupled with a week of lovely, and largely smog-free, California weather, added up to a highly successful ARS Semi-Annual Meeting at the Ambassador Hotel here May 9–12.

The meeting drew a total attendance of more than 4000—a tribute to the efforts of Tom B. Carvey Jr. of Hughes, general chairman of the meeting, the ARS Southern California Section, host for the meeting, and its president, William L. Rogers of Aerojet. Registration of 2200 ARS members and guests for the technical sessions, and upward of 1800 for the Astronautical Exposition, Marketing Symposium, and press conferences, marked the meeting.

The meeting got underway with a preview mixer on the evening of May 8 sponsored by 27 ARS corporate members. Technical sessions spanned the next four days. The technical content of the program was spread over 30 separate sessions, two of which were classified Secret—one on support equipment for mobile and hard launchers, and the other a panel discussion of the capabilities of liquid and solid engines. This panel produced the usual hot arguments.

The sessions covered such diverse subjects as hypersonics, missiles and space vehicles, lunar exploration, human factors in maintainability and trouble shooting, ion and plasma propulsion, propellants and combustion, latest events in space flight (a complete rundown on U.S. satellite and space-

The luncheons featured words of wisdom from ARS President Howard S. Seifert (left) of Stanford Univ., Maj. Gen. Don R. Ostrander (center), NASA's Director of Launch Vehicle Programs, and Bruce S. Old, (right), vice-president of Arthur D. Little, Inc.



The 1960 Semi-Annual Meeting was as big a success as these smiles from General Meeting Chairman Tom Carvey (left) of Hughes and ARS Southern California Section President William Rogers (right) of Aerojet-General.

The head table of the 30th Anniversary Commemorative Banquet, held during the Semi-Annual Meeting; beginning from far left on opposite page: John L. Sloop of NASA, Harold W. Ritchey of Thiokol, Roy Healy of Rocketdyne (ARS President—1942–43), Andrew G. Haley, of Haley, Wollenberg & Bader (ARS President—1954), Richard W. Porter of GE (ARS President—1955), Robert C. Truax of Aerojet-General (ARS President—1957), Banquet Speaker Jesse L. Greenstein, head of the CalTech Astrophysics Dept., Toastmaster G. Edward Pendray (ARS President—1932, 1934–36), Howard S. Seifert of Stanford Univ., (ARS President—1960), Noah S. Davis Jr. of Rocketdyne (ARS President—1956), F. C. Durant III of Avco (ARS President—1953), Lovell Lawrence of Chrysler (ARS President—1946), Alfred Africano of STL (ARS President—1937–40), Tom B. Carvey Jr. of Hughes Aircraft, and William L. Rogers of Aerojet-General.

probe data by Bruno Rossi of MIT at a special evening session which drew a large attendance), magnetohydrodynamics, instrumentation for combustion stability research, liquid rocket engines, support equipment, electrostatic propulsion, solid rockets, guidance and navigation, power systems, underwater propulsion (one of the few occasions on which this subject has been discussed in depth by outstanding experts in the field), space observation systems, space law and sociology, nuclear propulsion and instrumentation and controls for nuclear systems, astrodynamics, and education (a panel discussion chaired by F. C. Lindvall of CalTech and bringing together five important educators). In all, the 30 sessions produced more than 100 papers.

A high point of the meeting was the 30th Anniversary Commemorative Banquet of the ARS, held on Wednesday evening, May 11, and attended by some 750 ARS members and guests. The head table was graced by the presence of 10 ARS Presidents—Howard Seifert, the present incumbent, and nine of his predecessors: Roy Healy, Andrew G. Haley, Richard W. Porter, Robert C. Truax, G. Edward Pendray, Noah S. Davis Jr., F. C. Durant III, Lovell Lawrence, and Alfred Africano. Dr. Seifert presented ARS Fellow Memberships to six of this group—Haley, Porter, Truax, Durant, Lawrence, and Africano.

A. C. "Billie" Slade Retires

Dr. Pendray, one of the 12 founding members of the Society and its president in 1932 and 1934–36, acted as toastmaster at the banquet, and nostalgically reminisced over the early years of the ARS and its growth. To him fell the sad duty of announcing the retirement of A. C. (Billie) Slade, secretary and assistant treasurer of the Society, after 16 years with ARS. Billie, the Society's first paid employe (she recalled being inveigled into the job on a part-time basis by Dr. Pendray and of getting her first raise, from $50 to $75 a month), was presented with an appro- (CONTINUED ON PAGE 64)

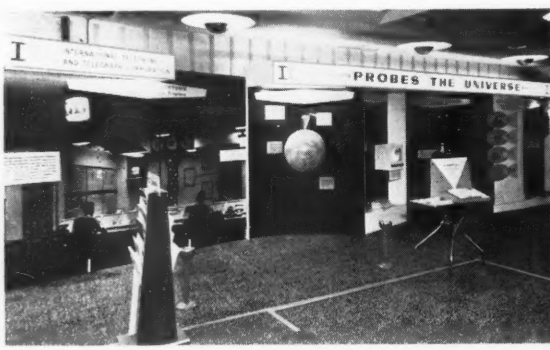
Kurt Stehling of NASA put zip into the Marketing Symposium, which he moderated, and was at his sparkling best toastmastering a lunch.

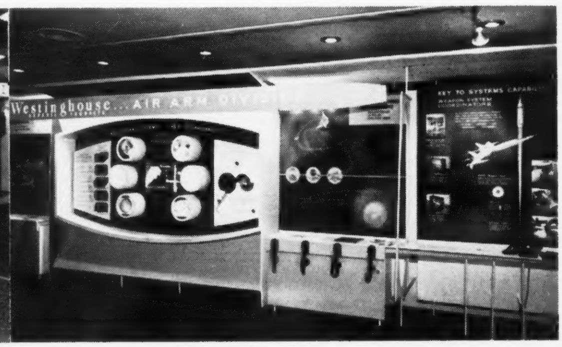
At the Section Delegates Conference, William Rogers, at the podium, follows through on points made by Conference Chairman Richard B. Canright of NASA, seated profile at his right.

A. C. "Billie" Slade as we all know her—registering attendees at the 1960 ARS Semi-Annual Meeting at the Ambassador in L.A.

Astronautical Exposition Scenes

The broad aisles of the Exposition provided ample room for viewers. Above, the McCormick Selph exhibit at far right and GE Rocket Engine Section in the foreground.





ITT stressed space communications. Westinghouse Air Arm Div. featured the company's advanced work on molecular electronic systems.

Convair Profits from Loss

Convair-Astronautics, whose exhibit for the ARS Astronautical Exposition was wrecked en route to Los Angeles, showed a good deal of light footwork by turning what could have been a debacle into one of the most talked-about "exhibits" at the show. The Convair exhibit staff set up a large lounge centered around a blackboard carrying the following note to Exposition visitors:

"We feel very small about this.

"Although we seem qualified to design vehicles for space travel, we also seem unable to arrange terrestrial means capable of shipping our exhibit booked for this space without its getting smashed to smithereens.

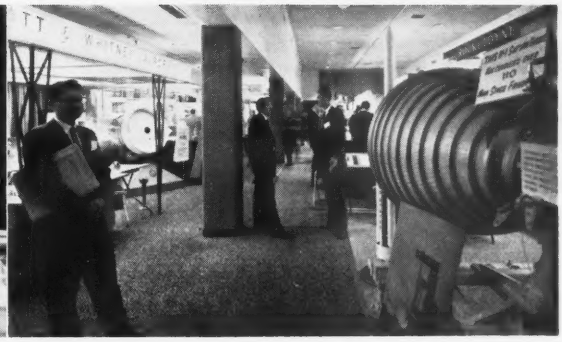
"Our apologies to ARS and a curled lip to the unknown freight handler who did us in.

"Meanwhile, please use our space to take the weight off your feet, if so inclined.

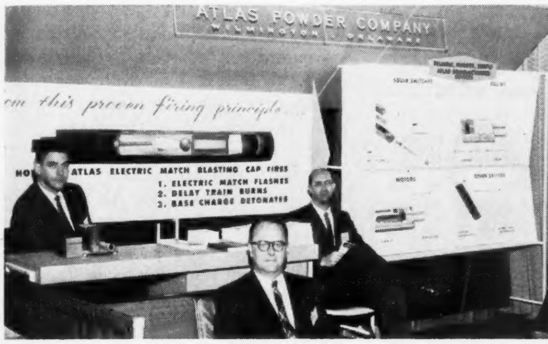
Convair-Astronautics"

As a final touch, Convair placed alongside the blackboard a floral wreath from Aero/Space Sales, Electric Autolite Co., carrying a card expressing its "heartfelt sympathy."

A little peek at North American's exhibit.



Linde explained one of its skills—handling cryogenic fluids. Pratt & Whitney and Rocketdyne showed liquid rocket systems.



Atlas Powder emphasized squib action; Johns-Manville, how to beat the heat with Min-Klad.

Hawk and Sparrow missile systems formed this part of a large Raytheon display. Stratoflex of Fort Worth called attention to important links for spacecraft and missiles.

Far left, Baldwin-Lima-Hamilton and, foreground, Burroughs Corp. underscored their broad competence in the missile and space fields. Western Gear showed what goes into the works.

"Billie" Slade Retires

AT THE 30th Anniversary Banquet of the AMERICAN ROCKET SOCIETY in Los Angeles on May 11, members of the Society heard the news that Mrs. Agnes "Billie" Slade, Secretary and Assistant Treasurer of the Society for more than 15 years, and one of the best-known people in the organization, was retiring to private life as of May 16.

Billie came to work for the Society formally in March 1945, after working for the Society on an informal basis beginning about December 1944. She was the Society's first paid employee. The income of the ARS at that time was so small it could afford to pay for only two days of her time each week.

It was, however, quite impossible for anyone of Mrs. Slade's energy, ambition, and devotion to restrict her activities to a part-time basis. She was soon devoting full time—and more —to the job, though some 18 months were to elapse before she received a raise in pay, from $50 to $75 per month.

When she first came to the ARS, its "office" was a small, airless, windowless cubby in a building which made a business of renting such cubicles to small-time real estate operators, manufacturers' representatives, and various other small enterprises. The ARS office had no telephone and little in the way of equipment, the latter consisting principally of one rickety desk and chair, a beat-up second-hand typewriter, a file, and a motor test stand designed and built by John Shesta for the ARS Experimental Committee.

Along with these assets, Billie was given charge of the books and records of the Society, consisting of various irregular entries in a school notebook and a list of about 1500 alleged members. Inspecting the records, she quickly made the discovery that the "members" had not been in the habit of paying their dues regularly. Thereupon she adopted her first and one of her most important policy rules: No pay, no membership.

This edict promptly reduced the membership of the Society to 237. Beginning with that basis, Billie began the promotional and membership activities of the Society which have since been continued with such success. The membership now is over 15,000—all paid up.

Her next big venture was to arrange for the Society to take space in the Engineering Societies Building, at 29 West 39th Street, New York City, in an office made available through the interest and aid of the American Society of Mechanical Engineers.

In these small but much more respectable new quarters, Billie added staff and equipment to keep up with the now growing membership and activities of the Society. She employed a part-time girl assistant to help with the office work. She added another typewriter, and later an addressograph, for by that time there were more than 500 members and hand addressing had become quite a task. She employed Jim Galloway to sell *Journal* advertising on the West Coast, and the firm of Emery and Harford in the East, thus laying the financial groundwork for the Society's two eminently successful publications, *Astronautics* and *ARS Journal*.

In October 1953, she took another highly significant step—one which was to have an important bearing on the future management and development of the Society. In that month she brought into the staff organization our present Executive Secretary, James Harford. His first work was to aid in membership development and service, and to improve the Society's income through better promotion of advertising. The results of his work were soon apparent, and the Society began to take on an increasingly substantial and professional tone.

In 30th Memorial Banquet ceremonies, G. Edward Pendray presents Mrs. Slade with a token of the Society's appreciation, inscribed as follows:

Presented in grateful appreciation to
MRS. A. C. "BILLIE" SLADE
AMERICAN ROCKET SOCIETY
1944–1960
On Behalf of the 15,000 Members of the Society
And the Presidents
Under whom she so ably served
On the Occasion of
The 30th Anniversary Banquet of ARS
Los Angeles, California, May 11, 1960

In 1946, at a time when the ARS treasury was little prepared for publishing gambles, Mrs. Slade conceived the idea of reproducing in book form Dr. Robert H. Goddard's classic Smithsonian papers: "A Method of Reaching Extreme Altitudes" and "Liquid-Propellant Rocket Development," both then out of print.

With the approval of Dr. Goddard, who wrote a special foreward for the book, and the Smithsonian Institution, which gave its blessing, the volume appeared in 1946 under the title "Rockets by Robert H. Goddard." The venture involved an investment of $2000, but Mrs. Slade so industriously promoted the book that advance sales paid the full cost of publication, and subsequent demand made it a modestly profitable publishing venture as well as a real contribution to the available literature on rocketry and astronautics. Copies of the ARS book continue in active demand, and the reprint to this day is the only source of Dr. Goddard's two famous papers in one handy package.

Mrs. Slade's other contributions to the growth and effectiveness of the Society are so numerous it would be difficult to identify them all.

Throughout her service she has been a tireless worker in the cause of astronautics and the ARS. She watched over the treasury and kept the Society solvent—a somewhat difficult feat at times. She established many of the procedures which have done so much to assure the Society's growth and success. She was the originator of most of its early policies, many of which are now basic to the character of the organization.

Her zeal and personality have also been reflected in the liveliness and smooth organization of the Society's meetings, where her unfailing good humor and vigorous style made her a well-known and much-beloved figure. AMERICAN ROCKET SOCIETY meetings are reputed to be better attended than those of most technical organizations. If this is true, perhaps it is because they are interestingly organized, well planned, and smoothly operated—features on which Mrs. Slade has insisted since the beginning of her service. The management of meetings, as well as the other activities of the Society, have now passed into other capable hands, but the impress of Mrs. Slade's methods, policies, and personality will long be upon them.

At the 30th Anniversary Banquet, Mrs. Slade's many contributions were

(CONTINUED ON PAGE 65)

At the Space Science Exposition, Explorer Scouts participated in many outdoor demonstrations, such as this one, and had explained such dramatic evidences of astronauatics as . . .

On target for tomorrow— The Explorer Scout Space Science Exposition

By Vincent S. Haneman Jr., CONSULTANT, DALLAS, TEX.
Laurel van der Wal, STAFF, STL, LOS ANGELES, CALIF.
Members, ARS Education Committee

. . . the X-15 and Tiros I, both of which were present in mockup form.

THE EXPLORER Scout Space Science Exposition, held recently in Los Angeles with great success, witnessed the inception of an ambitious ARS national youth education program. Before describing the events of this memorable Exposition, and related activities that will follow it, we would like to recount recent action of ARS in the field of youth education, and the steps that led to our participation in the Exposition.

At the ARS Board meeting in Washington last November, a resolution was unanimously passed directing the Education Committee to "encourage responsible youth organizations to undertake, on their own, educational programs along safe lines" in amateur astronautics. This project is in accord with the directive and the more general requirement that the Committee "inform youth and the public of the importance of the basic sciences."

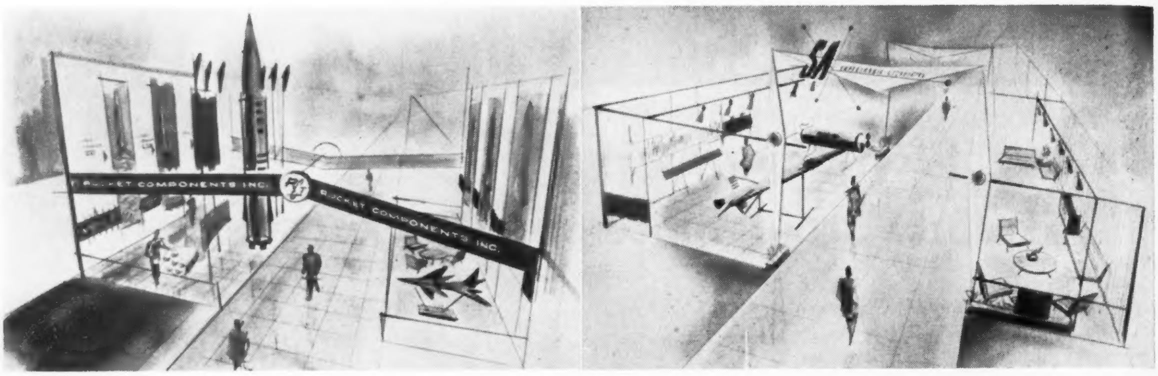
The over-all program, being set up by the Education Committee, under direction of Chairman Irving Michelson of Pennsylvania State Univ., will provide technical background and current information, on request, to organized youth groups, to students in local school systems, and to groups of teachers and parents (who want to keep not more than one jump behind the youngsters).

To meet the separate and distinct needs of these three categories of astronautics buffs, the Education Committee's Panel on Educational Methods, headed by N. Elliott Felt Jr. of Martin-Baltimore, is preparing a variety of lecture series, speakers lists, source references for movies, etc. for use by local ARS Sections throughout the nation. In addition, the Education Committee will assist the Sections in enlisting cooperation of industry, educational organizations, military establishments, etc. to provide appropriate literature, plant tours, field trips, use of facilities for special projects, and other elements of local programs which can best be supplied through these sources.

It is evident that this activity requires a tremendous amount of time and effort from many people if the Society is to do a reasonably complete and effective job of fulfilling its obli-
(CONTINUED ON PAGE 68)

Arnold C. Sorenson, Scout Executive, presented ARS President Howard Seifert with a plaque honoring him and the Society for interest in youth activities.

ARS news



These sketches show how each exhibitor will have facing booths in the New York Coliseum for the ARS SPACE FLIGHT REPORT TO THE NATION. Without competing booths facing each other, the aisles are expected to stay relatively open and comfortable.

Exhibitors Committee Formed for 1961 ARS SPACE FLIGHT REPORT TO THE NATION

Allocation of exhibit space at the **ARS Space Flight Report to the Nation**, to be held at the New York Coliseum October 9–12, 1961, began at the recent Semi-Annual Meeting in Los Angeles.

At the same time, ARS announced the forming of an Exhibitors Advisory Committee. This committee held its first meeting Sunday, May 8, and elected Eugene Palino of Douglas Aircraft as chairman and D. E. Knight of IBM Federal Systems Div. as vice-chairman. Mr. Palino was subsequently appointed a member of the Program Committee.

The first meeting of the Advisory Committee was a lively one devoted to an exploration of its objectives and the broad purposes of the **Space Flight Report to the Nation.** It was voted that Mr. Palino would individually poll the membership of the committee, composed of 17 representatives of both large and small East and West Coast companies to define the goals of the group and its method of operation.

Space reservations for the 1961 meeting were initiated at the Advisory Committee meeting and booth orders were taken throughout the remainder of the week. (The Exposition will be managed by the Robert T. Kenworthy, Inc., 10 East 40th St., New York 16, N. Y. Copies of the floor plans are available upon request.)

With the **Space Flight Report to the Nation**, the ARS will enter a new realm of meetings. Though moving to larger quarters, the dignified atmosphere that has surrounded ARS meetings in the past will be maintained. The fourth floor of the building will be devoted solely to technical sessions. The lower three will be occupied by the Exposition. Six special meeting rooms are being constructed by the Coliseum management on the fourth floor, and all halls will be carpeted. Plans call for special lounge areas comfortably furnished. Walls will display space-theme art.

The feature of the main floor will be an 80 x 50-ft display of the government's programs in space and will be flanked by an entire floor of island-type booths.

To prevent the confusion that usually accompanies large expositions, on the other exhibit floors, ARS will eliminate the customary booth-facing-booth arrangement. Instead, an exhibitor's booth will be split by the aisle with part on one side and the remainder on the other, as shown in the sketches above.

Liquid-Propellants Conference To Be Held This Month at Ohio State Univ.

Three sessions on liquid rockets will be a feature of the ARS Propellants and Liquid Rockets Conference scheduled for July 18–19 at Ohio State Univ., Columbus, Ohio.

The Conference will be similar in format to last year's, with double morning and afternoon sessions scheduled in the Ohio Union building.

Some 28 papers are scheduled for presentation, covering such topics as liquid rocket engine components, systems and performance, monopropellants, properties and thermodynamics, storable propellants, and engines and combustion.

In addition to the technical program there will be two luncheons and a banquet. The Monday luncheon will be addressed by Karl E. Krill, associate to the vice-president for instruction and research of Ohio State Univ., who will speak on "Problems of Research and Development."

On Tuesday, Emerson W. Smith,

chief of power systems at North American's Columbus Div., will speak on "Why is There a Space Problem?" Both luncheons will be held in the Franklin Room of the Ohio Union. The banquet is scheduled for Monday evening in the Deshler-Hilton Hotel in downtown Columbus. The speaker will be announced. The meeting program follows:

MONDAY, JULY 18

Liquid Rocket Engine Components

9:00 a.m. — **East Ballroom, Ohio Union**

Chairman: Paul D. Castenholz, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif.

Vice-Chairman: Marion L. Smith, College of Engineering, Ohio State Univ., Columbus, Ohio.

✦Analysis of Pressure Feasibility Limits in Regenerative Cooling of Combustion Chambers for Large Thrust Rockets, Ernest Mayer, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (1240-60)

✦Design Features of the X-15 Turbopump, S. R. Matos, Reaction Motors, Div. of Thiokol Chemical Corp., Denville, N. J. (1241-60)

Monopropellants

9:00 a.m. — **Conference Theatre, Ohio Union**

Chairman: Charles J. Marsel, New York Univ., New York, N. Y.

Vice-Chairman: John D. Clark, U. S. Naval Air Rocket Test Station, Lake Denmark, Dover, N. J.

✦Monopropellant Problems, Philip Pomerantz, Bureau of Naval Weapons, Dept. of Navy, Washington, D. C., and T. T. Sjoblom, Technical Research Associates, Hicksville, N. Y. (1244-60)

✦The Utilization of Sensitivity Data Obtained from JANAF—Recommended Liquid-Propellant Test Methods, William A. Cuddy, Wyandotte Chemical Corp., Wyandotte, Mich. (1245-60)

✦Design of Catalyst Packs for the Decomposition of Hydrogen Peroxide, Noah S. Davis Jr., Rocketdyne, North American Aviation, Inc., Canoga Park, Calif., and James C. McCormick, Becco Chemical Div., Food Machinery and Chemical Corp., Buffalo, N. Y. (1246-60)

✦Consideration of Hydrazine Decomposition, I. J. Iberstein and Irvin Glassman, Princeton Univ., Princeton, N. J. (1247-60)

✦Detonation Kinetics of Ozone and Nitric Oxide, E. Stokes Fishburne and Rudolph Edse, The Ohio State Univ., Columbus, Ohio. (1248-60)

Luncheon

12:00 Noon — **Franklin Room, Ohio Union**

Toastmaster: Alexis W. Lemmon Jr., Assistant Chief, Chemical Engineering Research, Battelle Memorial Institute, Columbus, Ohio.

Introduction: Harold A. Bolz, Dean, College of Engineering, Ohio State Univ., Columbus, Ohio.

Speaker: Karl E. Krill, Associate to the Vice-President—Instruction and Research, Ohio State Univ., Columbus, Ohio.

Subject: "Problems of Research Development."

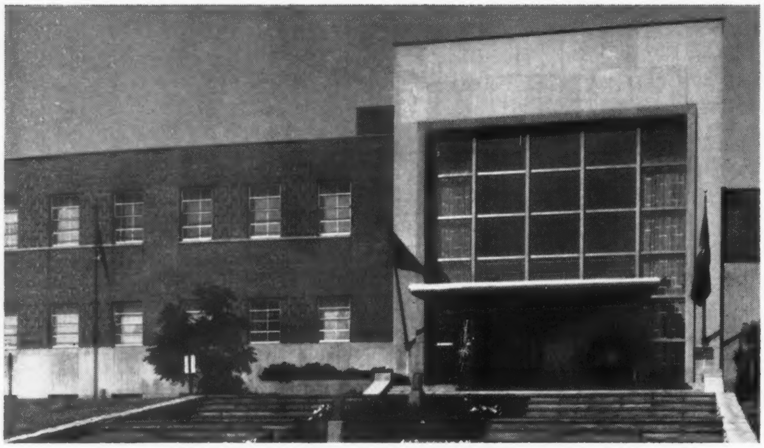
On the calendar

1960

July 10–22	Underwater Missile Engineering Seminar, Pennsylvania State Univ., University Park, Pa.
July 18–19	**ARS Propellants, Combustion, and Liquid Rockets Conference, Ohio State Univ., Columbus.**
July 18–29	Rarefied Gas Dynamics Course, Univ. of California, Berkeley.
July 21–27	3rd International Conference on Medical Electronics, sponsored by Institution of Electrical Engineers and International Federation for Medical Electronics, Olympia, London.
July 25–Aug. 5	Thermochemistry of Rocket Propulsion, a short course held at the Univ. of California Engineering Bldg., Los Angeles.
Aug. 3–6	Intl. Symposium on Rarefied Gas Dynamics, Univ. of Calif., Berkeley.
Aug. 8–11	American Astronautical Society Western National Meeting, Olympic Hotel, Seattle, Wash.
Aug. 8–12	AIEE 1960 Pacific General Meeting, El Cortes Hotel, San Diego, Calif.
Aug. 15–20	**11th International Astronautical Congress, Stockholm, Sweden.**
Aug. 15–26	Summer Institute on Nondestructive Testing, Sacramento State College, San Francisco.
Aug. 23–25	1960 Cryogenic Engineering Conference, Univ. of Colorado, Boulder, Colo.
Aug. 29–Sept. 2	The Combustion Institute 8th International Symposium on Combustion, CalTech, Pasadena, Calif.
Aug. 31–Sept. 7	10th International Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.
Sept. 15–16	Annual Meeting of Armed Forces Chemical Assn., Sheraton-Park Hotel, Washington, D.C.
Sept. 19–21	1960 IRE National Symposium on Space Electronics and Telemetry, Shoreham Hotel, Washington, D.C.
Sept. 21–25	Air Force Assn. National Convention and Aerospace Panorama, San Francisco.
Sept. 26–30	3rd ISA Instrument-Automation Conference and Exhibit, N.Y. Coliseum, N.Y.C.
Sept. 27–30	**ARS Power Systems Conference, Miramar Hotel, Santa Monica, Calif.**
Oct. 3–5	IRE Annual Meeting of the Professional Group on Nuclear Science, Gatlinburg, Tenn., sponsored by PGNS and Oak Ridge National Lab.
Oct. 4–6	IRE Conference on Radio Interference Reduction, Chicago, Ill.
Oct. 5	Technical Conference on "Plastics vs. Corrosion," sponsored by Society of Plastics Engineers, Mark Hopkins Hotel, San Francisco.
Oct. 10–12	**ARS Human Factors and Bioastronautics Conference, Biltmore Hotel, Dayton, Ohio.**
Oct. 12–14	AF Symposium on Astronautics, sponsored by AFOSR and Society of Automotive Engineers, Ambassador Hotel, Los Angeles.
Oct. 20–21	Hypervelocity Projection Techniques Conference, Univ. of Denver, Colorado.
Oct. 24–26	Medical and Biological Aspects of the Energies of Space Symposium, sponsored by USAF Aerospace Medical Center (ATC), Hilton Hotel, San Antonio, Tex.
Oct. 26–27	1960 Computer Applications Symposium sponsored by Armour Research Foundation, Morrison Hotel, Chicago.
Oct. 27–28	IRE Professional Group on Electron Devices Meeting, Shoreham Hotel, Washington, D.C.
Nov. 15–16	Symposium on Engineering Application of Probability and Random Function Theory, Purdue Univ., Lafayette, Ind.
Dec. 5–8	**ARS Annual Meeting and Astronautical Exposition, Shoreham Hotel, Washington, D.C.**
Dec. 13–15	Annual Eastern Joint Computer Conference, Hotel New Yorker and Manhattan Center, New York, N.Y.

1961

March 27–31	National Symposium on Temperature—Its Measurements and Control in Science and Industry, sponsored by American Institute of Physics, ISA, and NBS, Columbus, Ohio.
April 18–20	International Symposium on Chemical Reactions in the Lower Atmosphere, sponsored by Stanford Research Institute, Mark Hopkins Hotel, San Francisco.



Main entrance to the Ohio Union.

Liquid Rocket Engine Systems

2:00 p.m. **East Ballroom Ohio Union**

Chairman: D. A. Dooley; Space Technology Laboratories, Inc., Los Angeles, Calif.
Vice-Chairman: Kenneth E. Kissell, Aeronautical Research Laboratories, Air Force Research Div., Wright-Patterson AFB, Ohio.

✦Thor Engine Qualification Testing Results, N. Dale Johnson, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (1249-60)
✦Selection of a Pressurization System for a Storable Liquid-Propellant Rocket Engine, C. Kaplan, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (1250-60)
✦Propellant Utilization—Thor Weapon System, Arthur L. Andrews, Douglas Aircraft Co., Santa Monica, Calif. (1251-60)
✦Experimental Development of a Tap-Off Rocket-Engine System, Clifford A. Hauenstein, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (1252-60)

Properties and Thermodynamics

2:00 p.m. **Conference Theatre Ohio Union**

Chairman: J. D. MacKenzie, General Electric Research Laboratory, Schenectady, N. Y.
Vice-Chairman: Rudolph Edse, The Ohio State Univ., Columbus, Ohio.

✦The Oxidation of Boron Hydrides, W. H. Bauer, Rensselaer Polytechnic Institute, Troy, N.Y. (1253-60)
✦Ozone. A. Review, Charles K. Hersh, Armour Research Foundation, Chicago, Ill. (1254-60)
✦Spectroscopic Techniques for the Determination of Flame Temperatures, George Misko, Rocketdyne, North American Aviation, Inc., Canago Park, Calif. (1255-60)
✦An Integrated Propellant Performance Analysis Program, Stanley F. Sarner, General Electric Flight Propulsion Laboratory, Evendale, Ohio. (1256-60)

Reception

6:30 p.m. **East and South Foyer Deshier-Hilton Hotel**

(For those holding banquet tickets)
Sponsored by
North American Aviation, Inc.
Columbus Division

Banquet

7:30 p.m. **Grand Ballroom Deshler-Hilton Hotel**

Toastmaster: Loren E. Bollinger, Assistant Professor, Dept. of Aeronautical Engineering, Ohio State Univ., Columbus, Ohio.
Speaker: Roy E. Marquardt, President Marquardt Corp., Van Nuys, Calif.
Subject: "Propulsion Challenges during the Sixties"

TUESDAY, JULY 19

Liquid Rocket Engine Performance

9:00 a.m. **East Ballroom Ohio Union**

Chairman: E. Lynn Wilson, Douglas Aircraft Co., Santa Monica, Calif.
Vice-Chairman: George R. Gehrkens, North American Aviation, Inc., Columbus Div., Ohio.

✦Starting Transients of Hypergolic Bi-Propellant Rockets, J. A. Peterson, Tapco Group, Thompson Ramo Wooldridge, Inc., Los Angeles, Calif. (1257-60)
✦Experimental Investigation of Exhaust Diffusers for Rocket Engines, Paul F. Massier and E. John Roschke, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif. (1258-60)

Storable Propellants
Part I

9:00 a.m. **Conference Theatre Ohio Union**

Chairman: Clair M. Beighley, Aerojet-General Corp., Sacramento, Calif.
Vice-Chairman: Lt. William A. Gaubatz, U.S. Air Force Flight Test Center, Edwards AFB, Calif.

✦Comparative Applicability of Storable Propellants, Julius Jortner, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (1261-60)
✦Liquid-Propellant Comparison Based on Vehicle Performance, J. A. Gibb and J. A. Mellish, Aerojet-General Corp., Sacramento, Calif. (1262-60)
✦Testing with Storables, Daniel M. Tenenbaum, Aerojet-General Corp., Sacramento, Calif. (1263-60)

Luncheon

12:00 Noon **Franklin Room Ohio Union**

Toastmaster: Martin Goldsmith, Aero-Astronautic Dept., Rand Corporation, Santa Monica, Calif.
Introduction: Robert E. Kibele, Manager of Systems Engineering, North American Aviation, Inc., Columbus Div., Ohio.
Speaker: Emerson W. Smith, Chief of Power Systems, North American Aviation, Inc., Columbus Div., Ohio.
Subject: "Why is There a Space Problem?"

Engines and Combustion

2:00 p.m. **East Ballroom Ohio Union**

Chairman: Col. Frank J. Seiler, Air Research and Development Command, Washington, D.C.
Vice-Chairman: Frederick L. Bagby, Battelle Memorial Institute, Columbus, Ohio.

✦Variable Thrust Rocket Engines, Frederick R. Hickerson and Mario William Cardullo, U. S. Naval Air Rocket Test Station, Lake Denmark, Dover, N. J. (1264-60)
✦A Survey of Chemical Reaction in Nozzles, S. A. Greene and R. L. Wilkins, Rocketdyne, Div. of North American Aviation, Inc., Canoga Park, Calif. (1265-60)
✦The Size Distribution and Velocity of Ethanol Drops in a Rocket Combustor Burning Ethanol and Liquid Oxygen, R. D. Ingebo, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio. (1266-60)
✦An Experimental Study of RP-1, UDMH and N_2H_4 Single-Droplet Burning in Air and in Oxygen, O. W. Dykema and S. A. Greene, Rocketdyne, North American Aviation, Inc., Canoga Park, Calif. (1267-60)

Storable Propellants
Part II

2:00 p.m. **Conference Theatre Ohio Union**

Chairman: Howard P. Barfield, U.S. Air Force Flight Test Center, Edwards AFB, Calif.
Vice-Chairman: John W. Clegg, Battelle Memorial Institute, Columbus, Ohio.

✦Storable Hybrid Propulsion Systems, F. J. Hendel, Aerojet-General Corp., Azusa, Calif. (1268-60)
✦The Development of Packaged Liquid Propellants, Stanley Tannenbaum, Reaction Motors Div., Thiokol Chemical Corp., Denville, N. J. (1269-60)
✦Experimental Evaluation of New Storables, James A. Bottorff, Aerojet-General, Azusa, Calif. (1270-60)

High-Energy Propellants

2:00 p.m. **Room 331 Ohio Union**

Chairman: Martin Goldsmith, Rand Corp., Santa Monica, Calif.

✦The Ultimate Chemical Propellant, Robert M. Bridgforth Jr., Richard W. Carkeek, William H. McLain, and Robert E., Chase, Boeing Airplane Co., Seattle, Wash. (1271-60)

(Presentation and prepared discussion of a radical new propellant system.)

LADIES PROGRAM

The following activities have been planned by the Women's Auxiliary of the ARS Columbus Section for ladies attending the Conference.

MONDAY, JULY 18

9:00–10:30 a.m.

Registration

Registration desk will be located in the Ohio Union of Ohio State Univ. Coffee hour

in Buckeye Lounge of the Ohio Union.

Tour A **10:30 a.m.**

Westerville

Trip to historical Westerville, including Hanby House and Kyoto Tea House. Dutch luncheon.

Cost: $1.50
Children No Charge

6:30 p.m.

Reception and Banquet—Foyer and Grand Ballroom
Deshler-Hilton Hotel
Ticket: $7.00

TUESDAY, JULY 19

Tour B **10:30 a.m.**

Bridge-Swimming Party

Bridge-Swimming party at the new Nationwide Inn. Informal luncheon. Reservations for this luncheon must be made by noon on July 18.

Cost: $4.00

Arrangements will be made for children attending.

Purdue U. to Hold Symposia

A two-day Symposium on Engineering Application of Probability and Random Function Theory will be held at Purdue Univ., Lafayette, Ind., on November 15–16. On April 12–14, 1961, the university will sponsor a third Symposium on Information and Decision Processes—bringing together experts in the field on the applications of quantitative concepts to the basic questions involving communications, information processing, and decision making.

Student Chapter Chartered At Univ. of Pittsburgh

Stewart May, right, a director of the Pittsburgh Section, presents the charter for the new Univ. of Pittsburgh Student Chapter to its first president, Robert S. Fatyol. Later, Dr. Way, who is manager of Westinghouse Research's flow and combustion section, spoke to the Chapter's members on MHD theory and applications.

Arrowhead Section Chartered

ARS National President Howard Seifert, right, presents the charter for the Arrowhead Section to its first president, John Gustavson of Grand Central Rocket Co., at dinner-meeting ceremonies held in Riverside, Calif., in May. Some 150 ARS members living about 100 miles east of Los Angeles make up the new Section.

New ARS Section At Pacific Missile Range

The Pacific Missile Range Section of the American Rocket Society recently received its Charter. Howard Seifert of Stanford Univ., ARS president, presented the Charter to the new Section, which has 116 civilian and military members.

During the chartering ceremonies, held at the Point Mugu Officers Club, three new officers were installed: L. E. Wood, chairman; John Masterson, vice-chairman; and Lt. Comdr. John Draim, USN, secretary-treasurer.

The new PMR Section draws membership from all of Ventura County except for Rocketdyne's Santa Susana installation.

First Czechoslovak Conference on Rocketry and Astronautics: A Report

Some participants in the first Czechoslovak Scientific Conference on Rocket Techniques and Astronautics: Prof. J. Bukovsky, Technische Hochschule, Pilsen, Czechoslovakia; Prof. Davorin Bazjanac, Technische Hochschule, Zagreb, Yugoslavia; Prof. Leonid I. Sedov, Academy of Sciences, U.S.S.R.; Prof. Rudolf Pesek, Czechoslovakia; Dr. George C. Szego, Space Technology Laboratories, U.S.A.; Prof. Zbigniew Paczkowski, Warsaw Polytechnic, Poland; and Prof. Bolansky, Technische Hochschule, Brno, Czechoslovakia.

The first Czechoslovak Scientific Conference on Rocket Techniques and Astronautics took place near Prague on April 22–23, 1960. It was my privilege to attend this Conference, thanks to the courtesy of the Presidium of the Czechoslovak Academy of Sciences. Representatives of the U.S.S.R., Yugoslavia, and Poland were also in attendance. The entire Conference took place at the lovely castle of Liblice, which is one of four chateaux belonging to the Czechoslovak Academy of Sciences.

Liblice is well-suited for the holding of scientific conferences inasmuch as the delegates can sleep and eat on the premises, so that all the more time is available for discussions. This castle was at one time the property of the celebrated Casanova. In the large oval conference room of the castle, there was a very comfortable arrangement for the various presentations.

Before the presentation of papers, visiting guests were introduced. The first visitor introduced was Leonid Sedov, who is this year's president of the International Astronautical Federation, Chairman of the Commission on Astronautics of the Academy of Sciences of the U.S.S.R., and a figure well-known to members of the ARS. I was introduced next, and thanks to some homework the night before plus some course work in Russian that I have been taking here in Los Angeles, I was able to give the Conference official greetings from the American Rocket Society, first in Russian (which brought down the house) then successively in German, Hungarian, and English. Thanks to cooperation from a number of U.S. companies, I was also able to present to the Czechoslovak Academy of Sciences a number of tokens of my visit. These included models of rocket engines and of large rockets, tables and handbooks, and some lapel pins. These were well received. Then Professor Paczkowski, representing Poland, was introduced, followed by Professor Bazjanac representing Yugoslavia. I was the only Western representative.

An extremely interesting and varied technical program then got underway. The papers presented were as follows:

Basic Sciences

E. Buchar, Geodetic Satellite: Problems, Possibilities, and Prospects.

Z. Ceplecha, Comparison of Physical Processes at Entry of Space Vehicles and Meteorites into Planetary Atmospheres.

V. Guth, Graphical Computation of the Orbits of Artificial Satellites by Means of Central Projection.

F. Link, The Phenomena at Collision of the Moon Probe with the Moon's Surface.

J. Mrazek, Atmospheric Whistles and Exospheric Emission as Means for Determination of Physical Characteristics of Earth's Environment.

R. Pesek, Working Charts for Rapid Determination of the Orbit of Artificial Satellite of an Arbitrary Celestial Body.

L. Sehnal, The Effects of Earth's Equatorial Flattening on the Motion of Artificial Satellites.

Engineering Sciences

F. Bauer, Correction of the Isentropic Gas Flow and Rocket-Nozzle Wall Contour Determination.

J. Bukovsky, Some Problems of Gas Dynamics and Thermokinetics at Re-entry of Satellites and Space Vehicles.

G. Szego (U.S.A.), Space Propulsion Systems and Their Characteristics.

A. Blaha, Problems of Large Ion Streams in Ion-Rocket Engine.

M. Ledvina, Chemical-Propellant Systems and Their Theoretical Limitations.

J. Schmidtmayer, Multistage Rockets.

M. Voda, Theory of Solid-Propellant Burning.

L. Sedov (U.S.S.R.), Answers to Previously Submitted Questions.

E. Chvojkova, Conditions of Communications on Short Waves in Astronautics.

J. Karpinsky and J. Tolman, Reception of the Signals of Lunik III.

Space Medicine

J. Holubar, Human Sense of Time.

Z. Novotny, The Effect of Full or Partial Weightless State on Living Organism.

Z. Servit, Abnormal Brain Reactions on Some Extraordinary Excitations and Their Experimental Determination.

J. Semotan, Mental Hygiene in Space Medicine.

Social Sciences

A. Kolman, Social and World-Outlook Consequences of Astronautics.

V. Kopal, Legal Problems in Astronautics and the Prospects of Their Regulation.

M. Potocny, UNO and the Peaceful Use of the Outer Space.

J. Busak, Radiocommunications and Cosmic Space Legal Problems.

Prof. Pesek tells me that this Conference will probably become a biennial event.

The various subdivisions of the Czechoslovak Academy of Sciences are extremely interested in the fields of rocketry and astronautics, and a great enthusiasm for scientific work in these fields was evident at the Conference.

Particularly interesting was the paper of Dr. Ceplecha, wherein there was described a program of multiple photographs taken from two points by two batteries of cameras of meteorites entering the earth's atmosphere. In Czechoslovakia there are only about 50 nights a year during which sufficient atmospheric clarity in the absence of the moon makes it possible to take such photographs. Only a few weeks ago, after eight years of work, the observatory workers in this field succeeded in taking pictures whereby the initial masses, the trajectories, and the ablation rates of meteorites were estimated.

Dr. Mrazek played some tapes of extremely interesting atmospheric whistles which have been recorded over a period of time. Prof. Sedov was good enough to answer a number of questions from the floor relating to the Soviet rocket program.

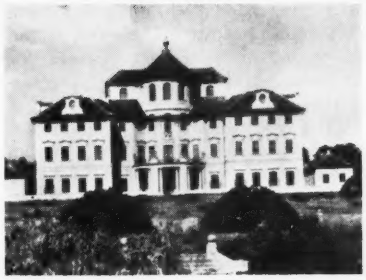
Professor Sedov drew to my attention the fact that the U.S.S.R. offers the triennial Tsiolkovskii Prize for outstanding work in rocketry and astronautics for which anyone, regardless of nationality, is eligible for nomination. The prize itself consists of a handsome solid gold medal about the size of a small saucer (for coffee, that is). The details of the Tsiolkovskii Prize appear on page 88 of this issue of *Astronautics.*

The Czechs are extremely active in space medicine, and some very interesting films were shown of their experiments in space- and aero-medicine. Dr. Servit showed some extremely interesting films of the effects on rats of vibration and acoustical noise, such as might be experienced during the launching and early powered phases of rocket flight.

Academician Kolman, who is head of the Philosophical Institute of the

Czechoslovak Academy of Sciences, gave an extremely interesting presentation regarding some of our obligations with respect to other civilizations in space. Prof. Kolman said that the conflict between the Socialistic and Capitalistic systems pales to insignificance, when one views the cosmos. He stated that we humans have an obligation to export to other worlds more than "syphilis and alcohol," and we should be sending some worthwhile culture. Prof. Kolman went on to point out that astronautics was indeed an area where these two systems of government could well work together. His views were widely reprinted in the Czechoslovak press.

The Czechoslovak Academy of Sciences plans an extensive program involving the launching of sounding rockets starting in about nine months. This work is to be carried forward under the direction of the Commission on Astronautics of the Czechoslovak Academy of Sciences under the Chairmanship of Professor Rudolf Pesek, well known to participants in past IAF Congresses.



The Castle of Liblice, near Prague, site of the Conference.

The day after the Congress, visitors were taken on a tour by the Academy of Sciences to the famous Castle of Karlstejn, to Pilsen, to Karlovy Vary (Carlsbad) and to Marienbad. On Monday, April 25, Prof. Bazjanac and I were taken on a visit to the Czechoslovak National Observatory at Ondrejov, where a great many interesting installations were inspected.

By direction, I was empowered to invite the Conference participants to the ARS Annual Meeting in Washington next November. The Commission on Astronautics of the Czechoslovak Academy of Sciences thanks the American Rocket Society for its good wishes and sends fraternal greetings to fellow rocket and astronautic scientists of the ARS.

The Conference, together with the hospitality of the Czechoslovak Academy of Sciences, made this an extremely worthwhile experience.

—George C. Szego

1500 Attend National Telemetering Conference

SANTA MONICA, CALIF.—The 1960 National Telemetering Conference, held at the Miramar Hotel here May 23–25, was an outstanding success, attracting an attendance of more than 1500, including 1100 technical participants and 400 exhibitor personnel, and pointing up the advantages of co-sponsorship of conferences of this type by several technical societies.

This year's conference, on the theme of "Telemetry—A Tool for Defense," was co-sponsored by ARS, AIEE, IAS, ISA, and IRE, and the program offered 18 technical sessions at which some 70 papers were presented. Included were three sessions devoted to industrial telemetry, including a workshop on "What We Really Need Is—." Another workshop, on the subject of missile and aircraft telemetry, discussed "R&D Needed in the '60's."

Other highlights of the meeting were the banquet, addressed by Lawrence L. Rauch, professor of aeronautical engineering at the Univ. of Michigan, also named winner of the telemetry man-of-the-year award, and two luncheons, addressed by William H. Pickering, director of NASA's Jet Propulsion Laboratory, and R. L. Johnson, chief engineer of the Douglas Missiles and Space Systems Div. A highly successful exhibit, featuring displays of telemetry equipment made by some 50 companies, was another important feature of the meeting.

One topic which came in for a good deal of discussion at the meeting was the upcoming shift of telemetering from VHF to the microwave regions, slated to be completed by 1970. Many of those present indicated the changeover would be an extremely difficult one, and expressed doubts that efficient microwave systems could be developed in the next 10 years.

In his luncheon address, Dr. Pickering hailed the intersociety meeting as a notable effort to keep down the number of conferences in a particular area, thus avoiding the growing drain on the time of professional engineers to attend such meetings. He also noted that the future is likely to see demands for greater reliability and accuracy, as well as long life and low-power operation. A need also exists for increased channel width and data-handling capacity, he pointed out, and, even more important, for production of data in usable form.

Conference Chairman Hugh Pruss of Telemetering Corp. of America, representing the ISA, host society for the meeting, announced that the conference, through its sponsoring societies, is setting up a Standards Activating Committee, which will recommend standards for the telemetering industry.

Chairman of the 1961 conference, to be held in Chicago May 22–24, will be Robert G. Brown of AC Spark Plug Div. of General Motors.

Fred Riddle of JPL has been named an ARS representative to the Conference Executive Committee. **—I.H.**

Fourth AGARD Combustion and Propulsion Colloquium Held

The 4th AGARD Colloquium took place in the picturesque museum of Leonardo da Vinci in Milan, Italy, on April 4–8 of this year. By delaying somewhat the publication of this report, we make it serve a dual purpose —a resume of the meeting and a timely advance notice of its proceedings, which by this time should be about to issue.

With the theme, "High Mach Number Air-Breathing Engines," the meeting drew representatives of almost all the NATO countries. It was chaired by S. S. Penner of CalTech and launched with an introductory address by Theodore von Karman, chairman of AGARD, who commented thusly on the purpose of the gathering: "At the present time we have operational civilian aircraft flying at Mach 0.8 to 0.9. Some military planes fly about twice this speed. A well-behaved missile cruises at M 10–20. It is certain that the intermediate flight ranges cannot be reached successfully without serious efforts by our best scientists and engineers. Fifteen years from now men may still be reluctant to have themselves 'shot' from Los

Angeles to Paris in one hour; they may prefer a leisurely trip of two-hour's duration, in order to enjoy an ample continental meal and to acclimate themselves properly to the European pace. Chances are that this terminal air-breathing craft will operate as a ramjet engine over most of its trajectory, flying perhaps at Mach 5–7."

Vice-Admiral J. T. Hayward, USN, fortified this opinion with the following comment: "Man has always dreamed of instant transport and will continue to strive to approach as closely as possible to his dream. The saying, 'Fastest with the mostest,' still applies, and I believe there is a requirement for both commercial and military transport with high Mach number. Assuming certain [technical] problems can be solved and considering the state of the art, it appears to me that for pure missile use, the conventional ramjet with a conventional rocket booster is the most suitable."

The general question of the future of air-breathing vehicles was discussed by Antonio Ferri of the Polytechnic Institute of Brooklyn. He expressed a belief that for short-range air travel, such as from New York to Washington, D.C., the most suitable means will be a vertical takeoff and landing airplane; that for long-range travel sufficient technical information is available today for airplane design in the Mach 2–3 range; and that to develop airplanes with a range of 6000 n. mi.—the median between the large cities of the world—an airplane must fly at Mach number of the order of 4 to 8, rather than 2 or 3. The propulsion system for such a purpose, he believes, would be made up of ramjet engines for cruise and turbojet engines for acceleration.

In a companion paper, Zipkin and Nuigi presented an analysis of a specific design indicating that definite improvement in performance can be obtained using combined air-breathing and rocket-powered stages during the initial acceleration over that of an all-rocket-power system. This includes air-launched satellites and sounding rockets.

The present status of hypersonic-ramjet development was summarized by J. A. Drakes. Gordon L. Dugger presented performance estimates for hypersonic combustion. He comes to the conclusion that the conventional subsonic engine should achieve overall efficiencies of 40 to 50 percent in the Mach 5–8 range, and should be capable of producing useful thrust to at least Mach 10, while with comparable component efficiencies the supersonic combustion ramjet should give better performance at speeds of Mach 8 to 10. The supersonic combustion engine may in addition, according to Dugger, provide a significant design advantage as a result of its lower combustion chamber pressures and temperatures.

Problems of hypersonic inlets were described by J. F. Connors, L. J. Oberly, and G. H. McLafferty.

Concerned with more fundamental aspects were the papers of Behren and Roessler on supersonic diffusion flames; Oppenheim and Stern on the development and structure of plane detonation waves; Wegener on the investigations of stationary supersonic nozzle flow with a reacting gas mixture; and Lezberg and Lancashire on the expansion of hydrogen air combustion products through a supersonic exhaust nozzle.

A comprehensive survey of the research in turbomachinery was presented by Horlock.

Finally, the materials limitation in high Mach number air-breathing engines was summarized by P. Duwez of CalTech, while Kennedy and Murphy of the United Kingdom described the temperature effects on material characteristics.

Significant to ARS was the fact that the meeting was attended by many of our members, including three Society directors—Maurice Zucrow, Bob Gross, and Tony Oppenheim.

—A. K. Oppenheim

1960 ARS Meeting Schedule

Date	Meeting	Location	Abstract Deadline
July 18–19	Liquid Rockets and Propellants Conference	Ohio State Univ.	Past
Aug. 15–20	11th International Astronautical Congress	Stockholm, Sweden	Past
Sept. 27–30	Power Systems Conference	Santa Monica, Calif.	Past
Oct. 10–12	Human Factors and Bioastronautics Conference	Dayton, Ohio	July 1
Dec. 5–8	ARS Annual Meeting and Astronautical Exposition	Washington, D.C.	Aug. 25

Send all abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

SAM Symposium Draws Attendance of 350

SAN ANTONIO, TEX.—Problems involved in making man an active and dynamic, rather than a passive, participant in space flight drew the focus of the Psychophysiological Aspects of Space Flight Symposium, held at the School of Aviation Medicine, AF Aerospace Medical Center, Brooks AFB, here May 26–27.

Some 350 persons attended the two-day meeting, sponsored by the School of Aviation Medicine and arranged by Southwest Research Institute. The 27 papers presented were grouped into four sessions, covering technical background and experience, critical problem areas, problems of human reliability, and special control techniques.

The program got underway on Thursday morning, May 26, with a welcoming address by Maj. Gen. Otis O. Benson Jr., commander of the Aerospace Medical Center, and a review of conference objectives by Lt. Col. Bernard E. Flaherty, chief of the SAM Neuropsychiatric Branch, the symposium co-chairmen.

The first technical session was divided into a review of technical objectives and requirements, as indicated by various manned astronautical missions, including Project Mercury, and a survey of biotechnologic problems and achievements. The second session centered on selection, training, and evaluation of space vehicle crews and the physiological problems involved.

Featured speaker at the banquet on Thursday evening was Clark T. Randt, director of NASA's Life Sciences Div.,

who briefly reviewed the organization, objectives and role of the division. Dr. Randt noted that the fiscal 1961 budget for the division would be about $5 million, with some 75 percent of this sum going to contracted basic research, and added that there was no intent to build a major NASA in-house research effort in this area.

The morning session the following day was also divided into two parts, the first centering on the effects of altered sensory input and sensory deprivation, and the second dealing with human performance under adverse conditions.

The afternoon session the same day produced the most controversial papers at the meeting. Topics discussed at the session included the possibility of "freezing" space travelers during long-term voyages, the use of hypnosis in conditioning future astronauts, and the possible physical alteration of the human body to adapt it to varying space environmental conditions.

Symposium proceedings are to be published by Columbia Univ. Press later this year.

Another SAM symposium, on the Medical and Biological Aspects of the Energies of Space, will be held Oct. 24–26. —I.H.

ARS Hypersonics Committee Accepting Papers Now

The ARS Hypersonics Committee has announced it will accept only one survey paper and five contributed papers of not more than 15 min in length for the single session the committee plans to sponsor at the ARS Annual Meeting to be held December 5–8 at the Shoreham Hotel, Washington, D.C. Engineers and scientists interested in giving a paper are urged to submit the entire manuscript by August 25 to: Meetings Manager, American Rocket Society, 500 Fifth Ave., N.Y. 36, N.Y. Manuscripts should contain complete details, but the oral presentation should be limited to 15 min and exclude details best left to the manuscript.

UCLA Film Series On Space Available

"Ballistic and Space Vehicle Systems"—a 16-mm filmed lecture series designed to supply fundamental and latest R&D information on systems engineering—is now available from the Univ. of California at Los Angeles. The series consists of 21 lectures divided into 15 programs with a total running time of approximately 28 hr. The series is available for rental in its

entirety for $2500. Each program in sequence is delivered on a Monday, and returnable the following Friday, over a 15-week period. During each weekly period, the renter can show the film as often as necessary.

Complete information and starting dates for the series can be obtained by writing or phoning the Dept. of Visual Communication, UCLA Extension, Univ. of California, Los Angeles 24, Calif.—BRadshaw 2-6161, Ext. 721.

McCormick Selph Associates Becomes Corporate Member

McCormick Selph Associates, Inc., of Hollister, Calif., has joined the growing number of ARS corporate members participating in Society activities. The firm is primarily active in the explosive ordnance field. Its specialty areas include: Solid-propellant gas generators; liquid- and solid-propellant igniters; propellant gas actuated systems and devices; squib, primer, and detonator type electric initiators; explosive bolts; safe/arm initiators; high-pressure electric terminals; exploding bridge-wire (EBW) initiators and systems; and destructors and pressure cartridges.

Named to represent the company in ARS activities are Donald A. McCormick, president; Frank W. LaHaye, vice-president; Sidney A. Moses, director of research and development; Hubert I. Bennett, director of applications engineering; and Robert F. Leinicke, principal engineer.

SECTION NEWS

Arrowhead: The Section received its charter on May 19 at a dinner meeting held at the Dinnerhorn Restaurant in Riverside, Calif. The Section's name is taken from the famous Lake Arrowhead region in the San Bernardino Mountains, located just north of Redlands, San Bernardino, and Riverside, where there are approximately 150 ARS members.

Some 110 members and guests were in attendance to watch the presentation of the charter by Howard Seifert, ARS national president. There followed the introduction of the newly elected corps of officers: John Gustavson, president; Louis Crider, vice-president; William H. Grip, secretary; and Douglas Melzer, treasurer.

Completing the evening was a thought-provoking talk on "Do Solid-Propellant Rockets Have a Future?" by Robert Truax, director of advanced development for Aerojet-General, Sacramento. He discussed current problems in liquid and solid rocket technology and the application of solids and liquids to future requirements. In addition, the Section was given an exclusive description of advanced activities at the world's most modern rocket development organization—"The Truax Rocket Company."

—William H. Grip

Cleveland-Akron: The Section recently elected the following officers for the 1960–61 season: Jim Skinner of Thompson-Ramo-Wooldridge, president; Harold Schmidt of NASA-Lewis, vice-president (Cleveland); Abe Tanenhause of Goodyear Aircraft, vice-president (Akron); and Dick Gido of Thompson-Ramo-Wooldridge, secretary-treasurer.

The April meeting was highlighted by a talk on "Gravity and the Principle of Equivalence" by Joshua Goldberg of WADD's Aeronautical Research Lab. As explained by Dr. Goldberg, Einstein's Principle of Equivalence postulates the precise equality between a uniform gravitational field and a constant acceleration. The Principle of Equivalence is the keystone of the Theory of General Relativity, which has as its basic premise the notion that motion, both uniform and nonuniform, can only be judged with respect to some system of reference—that is, absolute motion does not exist. Dr. Goldberg expects positive verification of the Principle of Equivalence within two years.

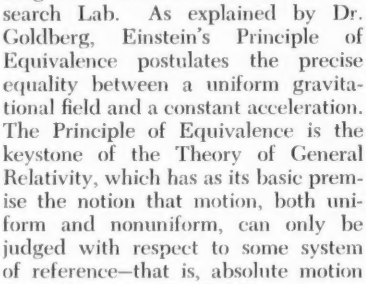
The meeting, held at the B. F. Goodrich Research Center, also featured a display of laminated fiber glass and plastic parts for solid-propellant rockets.

—Richard G. Gido

Fort Wayne: More than 90 members and guests attended the Chapter's annual dinner meeting in April. Guest speaker for the event was **Richard B. Kershner,** director of the Transit Navigation Satellite Program at the Applied Physics Laboratory of Johns Hopkins Univ. Dr. Kershner presented slides depicting the configuration and packaging design of the recently launched Transit 1B, and discussed problems of the satellite's temperature and frequency stabilization as well as the unique method utilized in reducing its spin and maintaining the proper orientation with respect to the earth's axis. Dr. Kershner also gave his view of "manned" space travel. He felt that much can be learned and accomplished with just instrumented flights before an astronaut is placed in orbit.

—Byron G. Hunter

Transit Talk



Richard B. Kershner, director of the Transit Navigation Satellite Program at the Applied Physics Laboratory of Johns Hopkins Univ., comments on Transit 1B for the press and television after discussing the satellite as guest speaker at the Fort Wayne Section's annual dinner meeting. Holding the mike is Tom Atkins of TV station WPTA.

Indiana: Capt. R. C. Truax, USN (Ret.), director of Advanced Development for the Liquid Rocket Plant of Aerojet-General, spoke to approximately 50 persons at the Tenth Anniversary Banquet of the Indiana Section, held in Lafayette, Ind., in May, on "Rockets, Then and Now." Frequently supplementing his talk with slides and motion pictures, he traced the development of rocketry from its beginning to the present, and then gave a few glimpses of possibilities for the future. Throughout the speech he discussed the economics involved in various types of programs for missiles, satellites, and more elaborate space flights.

Included in the program were talks by Purdue's H. L. Solberg, associate dean of engineering, and P. F. Chenea, head of the School of Mechanical Engineering. **M. J. Zucrow,** director of the Purdue Jet Propulsion Center, introduced the main speaker, and later received from Section President D. L. Crabtree a plaque for his service to the University and his students.

—George R. Schneiter

Pacific Northwest: A supersonic ramjet-powered aircraft or missile could get to an earth target faster than a ballistic missile. It would be just as hard to knock down as a ballistic missile and it could be called back if someone decided to stop a war.

These advantages of a ramjet-powered over a rocket-powered missile were cited by guest speaker **Roy Marquardt** in an address to the Section in April. "Getting someone to pay for the research it would take to develop such an engine seems to be a bigger challenge than the engineering," he said.

According to Marquardt, ramjet engines could handle many jobs. High-speed atmospheric cruise could be accomplished with a nuclear-fueled ramjet. Also, the inlet of a hyper-

sonic ramjet could be closed off and an oxidizer introduced, turning the ramjet into a rocket. As for space propulsion, Marquardt noted that a ramjet could operate in at least the atmosphere of one planet, Mars. "Mars has an atmosphere of 96 percent nitrogen," he said, "and we have a ramjet that will run efficiently in 96 percent nitrogen."

—Ken Calkins

Princeton: In May, the Section was treated to an open house and tour of the James Forrestal Research Center of Princeton Univ. Tours were conducted through the subsonic smoke tunnel, the 750-ft helicopter test track, the gas-dynamics laboratories (including supersonic and hypersonic wind tunnels), the flight-test hangar, and the jet-propulsion test area. Demonstrations were given of flow visualization with the smoke tunnel, rotor-stability tests in the helicopter track, ground-effect machines at the hangar, and rocket and plasma-jet firings in the jet-propulsion facility. A box lunch, served on the hangar apron, brought this enjoyable outing to a close.

Sacramento: The March dinner meeting was held at nearby Mather AFB and included a brief tour of that facility, in particular the planetarium and the navigation building, where navigators fly courses set by computer. J. J. Peterson introduced guest speaker **Major Gordon,** who discussed the Strategic Air Command and reviewed the problems facing SAC today: Technology, time, and survivability. Major Gordon concluded his address with one thought, "Peace Is Our Profession."

St. Joseph Valley: The March meeting was held jointly with the St. Joseph Valley Engineers Club. Our speaker was **John J. Martin,** chief engineer of the Advanced Research Laboratories of Bendix Products Div., who discussed kinematic, kinetic, and gas-dynamic aspects of defense against ballistic missiles. It is Dr. Martin's conclusion that the first-generation ballistic missile can be intercepted but that it would be a difficult job to do so.

The April meeting consisted of a tour through the Aeronautical Lab at Notre Dame Univ. The tour took in the supersonic and subsonic smoke tunnels and demonstrations of these. There were also demonstrations of flutter and the water-table analogy. The 35 members and guests in the tour enjoyed a beer and pizza get-together after the demonstrations.

—L. J. Boler

Tennessee: Fifty members of the Section toured Redstone Arsenal in May as guests of the Army and the Alabama Section of ARS. **Konrad Dannenberg,** president of the Alabama Section, was host. The visitors inspected the huge static-testing stand for the Saturn space booster.

The Tennessee party also toured the Redstone Div. of Thiokol, where they saw new government facilities, including a loading plant for solid-propellant rocket motors. Thiokol static-fired a small solid motor as a demonstration during the visit.

CORPORATE MEMBERS

ACF Industries has acquired a block of 214,000 common shares of **Republic Aviation,** representing about 15 percent of Republic shares outstanding . . . **Atlantic Research Corp.** has acquired Northeastern Engineering, Inc., a New Hampshire electronics manufacturing company . . . **Beckman & Whitley, Inc.,** has established within its Camera Products Dept. a new consulting service on high-speed photo instrumentation organized primarily around the applications of the Dynafax and Magnifax cameras . . . **Ford Motor Co.'s** Defense Products Group has opened a new Boston (Mass.) field office to service the New England area.

Haveg Industries, Inc., announces it has purchased Blow-O-Matic Corp. of Bridgeport, Conn., which blow-molds plastics, and will operate it as the Blow Molding Div. of Haveg . . . The Young Development Div. of **Hercules Powder** has been consolidated into the Explosives Dept. at Rocky Hill, N.J. . . . **Hoffman Electronics Corp.** has begun construction of a new 15,000-sq-ft Science Center in Santa Barbara, Calif. . . . **Hughes Aircraft** has opened its $225,000 advanced radar test center in Carbon Canyon, Calif. The company's Ground Systems Group has set up a computer laboratory with a staff of 600 at Fullerton, Calif.

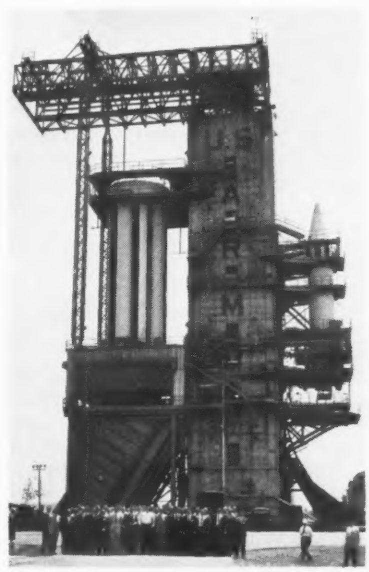
Northrop Corp.'s Nortronics Div. has broken ground for its new 50-acre scientific research center to be located in Palos Verdes Research Park in Los Angeles . . . A multimillion-dollar plant for production of anhydrous hydrazine will be built at Saltville, Va., by **Olin Mathieson Chemical Corp.** . . . **Philco's** Lansdale Div. has added a Special Products Operations as a separate organization within the division . . . **RCA** recently dedicated its new $6 million, 240,000-sq-ft electronics center at Van Nuys, Calif. . . .

First phase construction—national headquarters and electronic facilities at Palm Bay, Fla.—of proposed multimillion dollar building program was

The Future

Miss Connie Martin of Madison Junior High School in Mishawaka, Ind., receives a Moonwatch telescope for her winning project in astronautics—a scale model of the solar system—entered in the South Bend Science Fair. The telescope was sponsored as a prize by the St. Joseph Valley Section of ARS.

Don't Fire Now!



The 50 members of the Tennessee Section that recently toured Redstone Arsenal as guests of the Army and the Alabama Section pose in front of the huge test stand where the Saturn space booster, shown in position, is undergoing its first static firings.

dedicated by **Radiation Inc.** . . . **Raytheon** has signed an agreement to purchase Garlynn Engineering Co. of San Francisco. The Electronic Services Div. recently opened a new headquarters at Burlington, Mass. . . **Ryan Aeronautical** and the Ryan Electronics R&D facility have won national first place awards from the National Safety Council for no lost-time injuries during 1959.

Sperry Gyroscope inaugurated a year-long celebration on April 19 of the founding of the company 50 years ago and the birth of Dr. Elmer A. Sperry, its founder, 100 years ago . . . **Telecomputing Corp.** purchased the unacquired 13 percent of its Frank R. Cook Co. subsidiary, Denver, Colo. . . . The Army and **Thiokol**-Redstone Div. last month unveiled the company's new $4.5 million solid-propellant research, development, and manufacturing facilities at the arsenal . . .

Temco Aircraft merger with Ling-Altec Electronics, Inc., has been approved by both managements on basis of 1 share of Temco for $^6/_{10}$ of a share of LAE. It now goes to the respective stockholders . . . **Thompson Ramo Wooldridge** reports it is well along in negotiations with the AF for a complete reorientation of Space Technology Laboratoris role in the AF ballistic missile programs . . . Construction of a new Research and Engineering Center in Sunnyvale, Calif., a three-building complex for **United Technology Corp.**, has gotten underway. UTC's headquarters are now located at 587 Mathilda Ave., Sunnyvale, Calif . . . **Varian** has acquired 100 percent ownership of Semicon Associates, electronics firm, through an exchange of common stock . . . **Western Gear Corp.** announced that its Precision Products Div. has entered into the control field. ♦♦

Space vehicles and missiles on the lawn of the Ambassador Hotel announced the presence of the ARS Semi-Annual Meeting to Los Angeles citizens. From left, a Thor-Able, with Douglas' familiar booster; Aerojet-General's Able-Star upper stage, which features a restart engine; and far right, the Hawk ground-to-air missile, developed by Raytheon and now being produced in large numbers.

ARS Semi-Annual Meeting

(CONTINUED FROM PAGE 49)

priately inscribed Tiffany silver tray as a small token of the esteem in which she is held by all ARS members. (See page 52).

The banquet speaker was Jesse L. Greenstein, head of the CalTech Astrophysics Dept. and staff astronomer at the Mt. Wilson and Mt. Palomar Observatories, who spoke on "Two Worlds: The Universe from Below and Above the Atmosphere." Dr. Greenstein's address provided food for thought to space-flight enthusiasts. He noted, for example, that the fact that an experiment is done in space, the hard way, does not necessarily make it scientifically interesting, and that the great cost, in dollars, but even more important, in man-years of young scientists, requires that such research be worthy of the cost. He pointed out that, if space science is to be carried out, its value should be judged by the merit and depth of the research proposed, and suggested that one of the most important things to investigate was the strange, high-energy aspects of the universe, about which we know very little.

Dr. Seifert was the luncheon speaker on Monday, May 9, with ARS Southern California Section President Rogers as toastmaster. In his address, "Can We Decrease Our Entropy?," Dr. Seifert confronted the problem of how we can succeed in bringing about a maximum decrease in entropy or, in other words, a maximum amount of order out of chaos. He suggested a need for the universities to be bolder and less conventional and for the professional societies to break with tradition and be more flexible, and take the initiative in bringing together education, industry, and government to study the really challenging problems.

That same afternoon, representatives of more than half the ARS Sections and Student Chapters met at the Semi-Annual Section Delegates Conference to suggest ways and means of improving the Society's membership services. The meeting, chaired by R. B. Canright of NASA, vice-chairman of the ARS Membership Committee, produced a number of recommendations which were presented to the ARS Board at its meeting the following day.

Maj. Gen. Don Ostrander, director of NASA's Office of Launch Vehicle Programs, was the Tuesday luncheon speaker, with Kurt Stehling of NASA providing one of the more memorable moments of the meeting with a sparkling performance as toastmaster. The major portion of Gen. Ostrander's address will be found on page 22.

Another in the highly successful series of ARS marketing symposiums, held the same afternoon, produced a turnout of more than 250 persons, packing to the rafters the room in which it was held. The ubiquitous Kurt Stehling donned another hat and acted as moderator for a panel made up of Brig. Gen. Don Coupland (USAF), commander, Ballistic Missile Group, AMC; Edward G. Uhl, vice-president, Ryan Corp.; Harlowe J. Longfelder, development program manager, Boeing Aerospace Div.; and Edmund J. Richards, manager, Market Research, Thiokol Chemical Corp.

Tom Carvey was the toastmaster at the Wednesday luncheon, with Bruce S. Old, vice-president of Arthur D. Little, as the featured speaker. Dr. Old spoke on "A Pentagon for Progress." He dealt with a major challenge faced by our nation today, the problem of establishing better communications between five important groups—science, labor, management, politics, and the arts—without which the U.S. cannot make sufficiently rapid socio-economic progress in these times of international strife. He called on the Society to play a leading role in building this "pentagon of progress" without which the country could find itself in grave danger.

Those in attendance at the meeting were given a choice of three exciting field trips on Friday, May 13—classified Secret tours of the Edward AFB Rocket Test Center and of the North American B-70 mockup and an unclassified tour of the Rocketdyne Field Lab at Santa Susana. Members wives in attendance had a special program of ladies events, arranged by Mrs. Herbert Isaacs, which included a fashion show and tours of Marineland, Hollywood, and Disneyland.

The program was spiced with stimulating meetings of the ARS National Program, Policy, and Publications committees, as well as meetings of most of the ARS Technical Committees. The

one paramount effort evident at all these meetings was that aimed at continually increasing the quality of ARS programs.

The ARS Astronautical Exposition brought together almost 70 leading producers of systems, subsystems, components, and equipment now in use in the rocket, missile, and space-flight industry. A large number of new exhibits, especially prepared for the Exposition, highlighted the show. As an added attraction, a display, spotlighting a full-size Thor-Able vehicle, a Discoverer capsule, and an Aerojet Able-Star engine prepared for the Transit program, was set up on the Ambassador's front lawn. The first meeting of the ARS Exhibitors Advisory Committee, set up in anticipation of the 1961 ARS SPACE FLIGHT REPORT TO THE NATION (See page 54), also took place during the week-long activities.

GE's Missile and Space Vehicle Dept., in the persons of Ray Forbes, Bill Hoese, and Neal Lang, is also deserving of a pat on the back for its aid in running the press room at the meeting.

All in all, the 1960 Semi-Annual Meeting represented another major step forward in ARS meeting programming. ♦♦

"Billie" Slade Retires

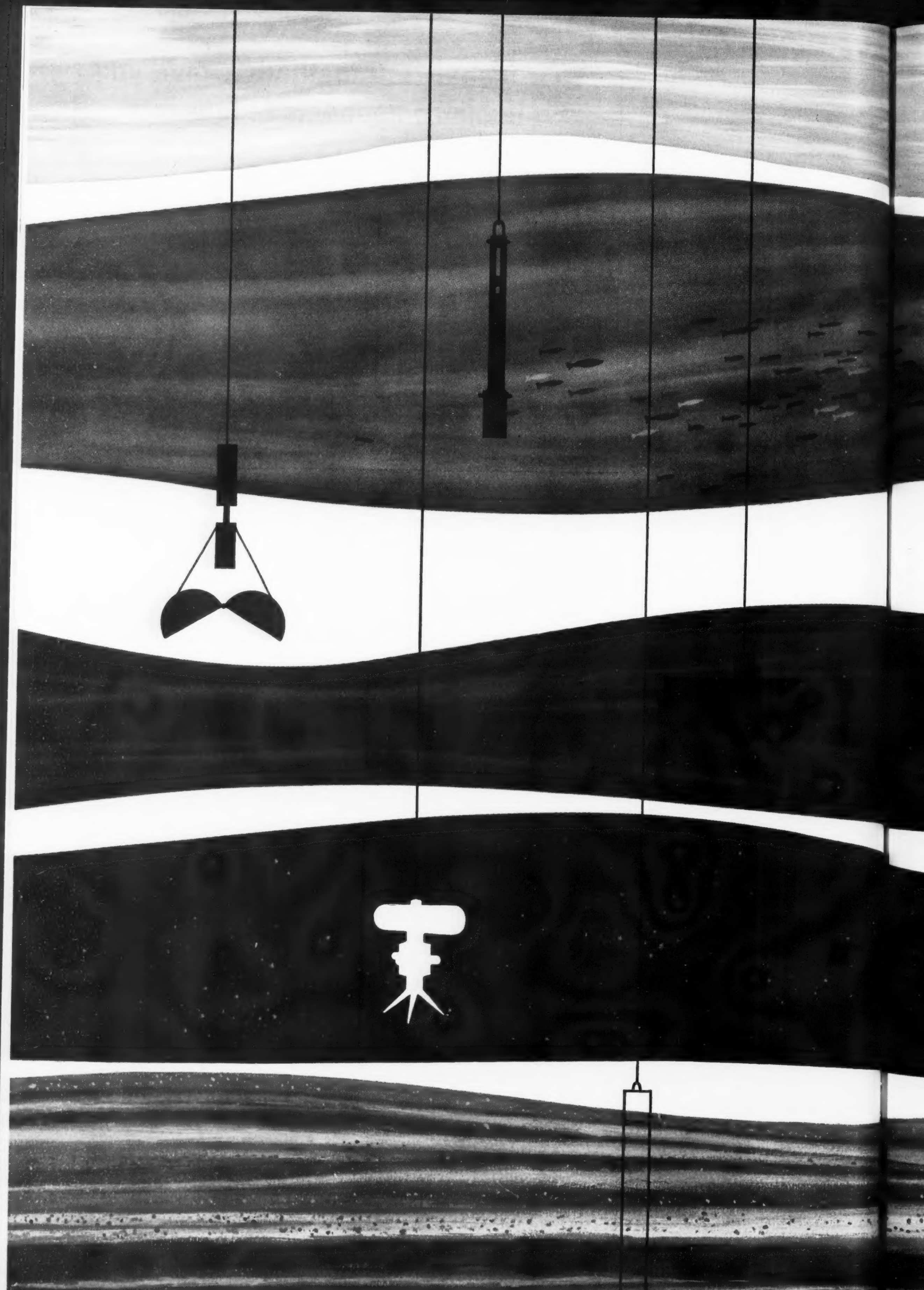
(CONTINUED FROM PAGE 52)

publicly acknowledged, amid a standing ovation from the more than 700 members present for the occasion. G. Edward Pendray, a founding member of ARS, had the pleasure of presenting Mrs. Slade with a token of the Society's appreciation on this occasion. The ARS Board of Directors formalized the Society's sentiments for the record as follows:

RESOLVED: That the Board of Directors of the AMERICAN ROCKET SOCIETY *does hereby extend its profound appreciation to Mrs. A. C. "Billie" Slade for her contributions to the Society and thereby to the nation's space-flight and rocket capability, through her tireless and indefatigable devotion to her work as Secretary and Assistant Treasurer from 1944 to 1960.* ♦♦

ARDC Basic Research

A 342-page summary index describing some 1400 basic research projects being sponsored by the AF Research and Development Command is available from the U.S. Dept. of Commerce, 350 5th Ave., New York 1, N.Y., at a cost of $5.00 each.



Lockheed's interest in the virtually unknown 360,000,000 cubic miles of this planet's oceans, stems naturally out of its underwater environmental development work with the Navy's POLARIS Fleet Ballistic Missile.

Proposed studies in the increasingly important field of oceanography include: oceanographic research vessels; measuring instruments; data collection systems; underwater communication and navigation; and basic research regarding natural phenomena and military aspects of the deep sea.

EXPLORING THE WORLD OF WATER

Division Diversification— Oceanography is typical of Lockheed Missiles and Space Division's broad diversification. The Division possesses complete capability in more than 40 areas of science and technology — from concept to operation. Its programs provide a fascinating challenge to creative engineers and scientists. They include: celestial mechanics; computer research and development; electromagnetic wave propagation and radiation; electronics; the flight sciences; human engineering; magnetodynamics; man in space; materials and processes; applied mathematics; operations research and analysis; ionic, nuclear and plasma propulsion and exotic fuels; sonics; space communications; space medicine; space navigation; and space physics.

Engineers and Scientists — Such programs reach far into the future and deal with unknown and stimulating environments. It is a rewarding future with a company that has an outstanding record of progress and achievement. If you are experienced in any of the above areas, or in related work, please write: Research and Development Staff, Dept. C-14, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense clearance required.

Lockheed

MISSILES AND SPACE DIVISION

Prime Contractor for the Navy POLARIS FBM; the Air Force AGENA Satellite in the DISCOVERER Program and the MIDAS and SAMOS Satellites; Air Force X-7; and Army KINGFISHER

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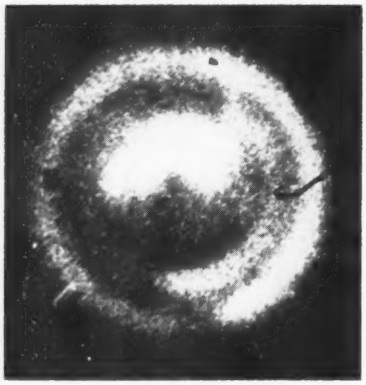


Sun's X-Ray Halo And Hot Spots

This first photo of the sun in its X-ray emission was taken from an Aerobee-Hi rocket fired to a height of 130 miles from White Sands Missile Range, in an experiment conducted by Ensign Richard L. Blake and Arlyn E. Unzicker of NRL. A simple pinhole camera was used because X-rays cannot be focused by lenses or mirrors. The coronal gas averages 1-million K with local hot spots of perhaps 10-million K.

Scout Science Exposition

(CONTINUED FROM PAGE 53)

gation to inform the American public of the meaning and significance of the Space Age. To date, this time and effort has been contributed largely by a small number of individuals. Those of us who have been involved in setting up the program consider it a unique opportunity for contributions to the encouragement of the coming generation's active participation in the development of space technology, through knowledge of the many individual disciplines which make up the science of astronautics.

In addition to this reason for being so deeply involved in the program, we are enjoying the effort. It is always a refreshing experience to work with young people, and it is especially exciting to work with bright, enthusiastic youngsters who can—and do—provide a contagious spark which is closely akin to the pioneering spirit most of us felt in the days when space travel was commonly classed as romantic science-fiction nonsense. Because the Youth Program is proving to be such a revitalizing experience to this bunch of paperbound engineers, we invite the Society membership to join us in spreading this activity into other areas of the country, through preliminary sectional programs.

To provide a guide for development of such programs, the Education Committee is now engaged in a pilot program in the Los Angeles area. Just prior to the Board meeting last November, and following the Youth Program Workshop held last September at Princeton, the ARS Southern California Section was informed by the Los Angeles Area Council of the Boy Scouts of America of a proposal made by the local architect-engineering firm of Daniel, Mann, Johnson and Mendenhall (DMJM) to establish an astronautics program with a selected group of Explorers (Scouts in the age group 14 to 18 years), with technical advice from the ARS. Following the Board's approval of the Youth Program resolution, this proposed Explorer Space Science Program was selected as a test case for ARS participation, and is now in full swing.

A Steering Committee was set up with representation from the Boy Scouts, DMJM (the program sponsor), and ARS. A Phase I committee was chaired by Harold Larsen, Explorer Cabinet Adviser and member of the BSA Executive Board. A Phase II committee was chaired by Thomas Carter, DMJM. The program received enthusiastic support from industry and from other professional societies.

The Exposition was held on May 7 in Los Angeles, and attracted an attendance of some 800 Explorer Scouts from the area. Morning activity consisted of formal registration, a welcoming address by Howard Seifert, national ARS president, and a series of brief addresses intended to acquaint the Explorers with the history, significance, and scope of astronautics. Speakers were Milton U. Clauser, vice-president and director, Physical Research Lab, STL; Arthur Kantrowitz, vice-president and director, Everett Research Lab, Avco; William L. Rogers, president, ARS Southern California Section and vice-president, Azusa Plant, Aerojet-General; and Capt. Bruce Pinc, (USAF), chief, Biomedical Div., Bioastronautics Directorate, AF Ballistic Missile Div.; and Al White, engineering test pilot, North American Aviation.

Following a series of discussions at the morning sessions, the Scouts studied more than 20 exhibits covering all phases of space technology. Included were models of Pioneer V and Tiros I, an operating space suit, and a mockup of the X-15.

During the Exposition, cards were distributed to sample the interest of the participating boys in continuing into Phase II of the program. This group of 200 boys participated in a two-day encampment at Vandenberg AFB on June 18–19, the weekend following termination of the current school year. The encampment provided an opportunity for Explorers with special interests to discuss these interests with specialists in the various component fields of astronautics drawn from the local ARS membership who accompanied the group on the trip. Both Saturday afternoon and Sunday morning were devoted to these informal discussions and technical tours of the site facilities for on-the-spot familiarization with astronautics in action.

During the encampment, plans for Phase III were presented to the group and applications for registration accepted. Thus far in the program, the Explorers have played an increasingly active role, culminating in the Space Science Seminar, which will require very active participation and a good deal of hard work from those who elect to continue in the program. It is expected that this hard-core group will number only about 100. Three or four subgroups will then be formed, probably on a geographic basis, to permit more individual attention during this final phase of the program.

Forty Meetings Scheduled

The Seminar will consist of a series of 40 evening or Saturday meetings, held biweekly during the 1960–61 school year. Each meeting will last about an hour and a half and will consist of two 40 min periods separated by a 10 min break. In general, the first period will be somewhat more basic in science and engineering content, the second period of each meeting will deal with applications of principles. The last five meetings will include time for development and construction of a Seminar project—in some cases a flyable rocket (sans propellant), but also conceivably a telemetry or tracking station, a test-stand facility, a space-capsule mockup, etc. In order to cover the material, homework assignments will be given and possibly a 5 min review quiz will start each meeting.

A special effort will be made to interest the boys in the many facets of astronautics which do not involve hazardous materials. It is hoped and believed that the Seminar projects selected by the subgroups will not include construction of flight-test rockets. Such do-it-yourself rockets are usually one-shot affairs, and it is anticipated that this select group of dedicated amateur astronauts will not be content with such a temporary

achievement to show for their months of hard work. Instead, they will probably choose to build a tracking station, an instrumented payload which may actually be carried aboard a space-research vehicle, a development and performance test facility for flight component hardware, etc.—in short, a project which has the potential of yielding a significant contribution to the state of the art.

ARS Policy

However, the possibility does exist that one of the groups—either in this program or in other later ones—will elect to build a rocket for flight test. In this regard, it must be stated clearly that in no case will any group receiving technical advice from the ARS be permitted to procure, develop, or work with hazardous rocket propellants. If a group elects to build a test vehicle, provision will be made to have the rocket loaded, static fired, and launched by the professional staff responsible for these functions at an established industrial or military missile launch site. The participating Explorers will, of course, comply with all safety regulations of the facility while observing the preparation, test, and flight of their rocket; they will not be permitted to assist in these operations, but will be assigned other specific essential duties such as preflight checkout in the blockhouse during the countdown, noting data for inclusion in the test report, and recording experimental data obtained from the flight. (Indeed, under California law, this is the legal limit of participation in rocket testing without fulfilling the requirements for a Pyrotechnics Operator License.)

Whatever the selected Seminar projects may be for the Phase III Seminar groups, it is hoped that sufficient interest will be generated during this pilot program to stimulate further study of astronautics by the participating Explorers. But our objective is not to divert large masses of young people into the engineering profession. Our aim is to acquaint this group, and those which follow, with the field of astronautics, the possibilities for direct contributions from every portion of society, and the effects to be expected from the impact of the Space Age in particular and science in general on our daily lives.

Your suggestions of how we might better achieve this goal are welcomed. Even more, *you* will be welcomed if you would like to join us in this most exciting undertaking. Our target for tomorrow is a well-educated generation capable of helping to make the world a better place in which to live.

♦♦

Atomic Clocks

(CONTINUED FROM PAGE 37)

stability in rugged environments.

The ammonia maser has excellent short-term stability and can probably be squeezed into a package with a volume of about $^1/_2$ cu ft. The main problem is that the frequency is affected rather strongly by the tuning of the microwave cavity in which the ammonia molecules radiate energy. This difficulty can be reduced by using coupled cavities to decrease the dependence on tuning and by using low temperature-coefficient materials, but the most promising solution is to use a magnetic-modulation scheme to keep the cavity tuned to the proper frequency. By this method, a resettability of 3 parts in 10^{11} has been achieved for laboratory ammonia masers. Commercial models of the ammonia maser are expected to be available soon.

The rubidium-vapor frequency standard is a relative newcomer to the field. The stability of preliminary versions has been checked only to about 1 part in 10^{10} at present. However, data on versions intended for higher stability should be available soon. A stability of 1 part in 10^{11} over extended periods is expected with simple and compact apparatus. The question of how long such stability can be maintained depends on the glass optical absorption cell containing the rubidium vapor and a buffer gas. The frequency of the device depends to some extent on the pressure and nature of the buffer gas. A leakage of about 10^{-4} mm Hg of almost any gas into or out of the cell would change the frequency by about 1 part in 10^{11}. Since 10^{-4} mm Hg is a fairly high pressure compared with the vacuum maintained for years in many vacuum tubes with metal parts, the frequency drift of the all-glass rubidium vapor cell is expected to be very slow. Rubidium-vapor frequency standards are under investigation at present in a number of laboratories, and some work is also being done using cesium or sodium as the active element instead of rubidium.

Of the three types of atomic frequency standards, the ammonia-maser and rubidium-vapor standards seem to have some advantage over the cesium beam in size and probably in weight. The rubidium-vapor standard appears to be simpler, though also less thoroughly tried out, than the other two. Each of the three devices can probably be run on 5 watts of power or less, assuming moderate ambient temperatures. The power requirements thus appear within the range of solar-battery operation.

A major use of these standards will be to check the General Theory of Relativity. The General Theory has been subjected to three experimental checks—the precession of the perihelion of Mercury, the deflection of light rays by the sun, and the gravitational frequency shift of atomic spectral lines emitted from the sun. However, in all three cases the measurements are difficult and the experimental uncertainty is almost as large as the effect being measured. A more accurate check of the predictions of the theory would be very desirable.

The expected gravitational shift between two identical frequency standards, according to the theory, is given by $\Delta\nu/\nu = \Delta\varphi/c^2$, where ν is the frequency used, $\Delta\nu$ is the shift, $\Delta\varphi$ is the difference in the gravitational potentials at the locations of the two standards, and c is the velocity of light. If one of the standards is on the earth's surface near the equator and the other is in a submarine near the north pole, or if one is in a balloon at high altitudes, the shift would be a few parts in 10^{12}. This will probably be within the range of observation within the next few years. However, an accurate check of the theory by these methods would be difficult.

Ginzburg, Singer, and Moller have pointed out that a much larger effect could be obtained by placing an atomic clock in an earth satellite. In this case, there is a second-order Doppler shift in the clock rate as well as the gravitational shift. The second-order Doppler shift, which is a Special Relativistic effect, has been demonstrated in the laboratory and can be regarded as a known correction. Its average value over an orbit is given by $\Delta\nu/\nu = \varphi_E/c^2\ [(1/2)R_E/a]$, where φ_E is the gravitational potential at the earth's surface, R_E is the earth's radius, and a is the semimajor axis of the satellite orbit. The total shift for the satellite clock with respect to the ground clock will be

$$\frac{\Delta\nu}{\nu} = \frac{\varphi_E}{c^2}\left(3/2\,\frac{R_E}{a} - 1\right) = 7 \times 10^{-10} \left[1 - (3/2)\,\frac{R_E}{a}\right]$$

For a satellite orbit with $a = 3R_E$, for example, a circular orbit with an altitude of 8000 miles, the total effect will be 3.5 parts in 10^{10}. The gravitational part of the shift would be 4.7 parts in 10^{10}, or 40 microsec per day. If the clock rate is known to 1 part in 10^{11}, the resulting time uncertainty will be 1 microsec per day. The uncertainty in direct 108-mc transmission of timing pulses to the ground is estimated to be about 5 microsec, and thus the experiment would have to be run for 10 days or more to make full use of the precision of the satellite clock. The use of higher transmission frequencies and more precise tracking methods would reduce the transmission time uncertainty considerably.

Badessa, Kent, and Nowell have suggested another method for checking the gravitational frequency shift. If a satellite containing a frequency standard is placed in a highly elliptical orbit, the gravitational and second-order Doppler shifts will give a difference in frequency between apogee and perigee. This effect would be completely masked by large first-order Doppler shifts if direct transmission to the ground were used without further precautions. By using a satellite transponder and a frequency subtraction scheme, however, it appears possible to cancel out almost all of the first-order shifts and to make accurate measurements of the satellite frequency in a period of less than a minute anywhere along the orbit. For this method, it is not necessary that the frequency of the satellite standard be exactly the same after launching as before. In fact, even a moderate uniform drift in frequency can be tolerated, since it can easily be separated from periodic changes due to position in orbit.

Two main types of tracking systems have been suggested for which the use of atomic standards may be desirable. In the Doppler-shift method, frequency measurements are made on transmissions from an atomic standard in the vehicle. The observed shift gives the outward velocity component, and the velocity curve can be integrated to give the distance. In the transmission-time ranging method, timing pulses from an atomic clock in the vehicle are observed to obtain the distance, and the distance values are differentiated to find the velocity. The two methods are, of course, basically similar in nature.

For tracking systems, atomic standards have two advantages over quartz-crystal oscillators. They are considerably less subject to frequency change during takeoff, and they show better frequency stability over long periods of time. Drift rates of 1 part in 10^{10} per week have been achieved for laboratory crystal oscillators; but for long vehicle flights this slow progressive change can cause large frequency errors. Crystal oscillators are now being developed which will regain their frequency after launching to about 1 part in 10^9, but this is one or two orders of magnitude poorer than can be done with atomic standards. For applications where stability during

launching is important, such as control of the launching vehicle, it also appears possible to gain an advantage by the use of atomic standards.

For space-vehicle tracking, the use of atomic standards or of quartz-crystal oscillators in the vehicle may both be less desirable than the use of a transponder in the vehicle and signals sent from the ground. However, particularly for long-range work, there is some question whether the power required to reradiate received noise can be kept down without complicating the transponder considerably. The decision on whether to use a transponder or a frequency standard for a particular experiment, as in the case of atomic versus quartz-crystal standards, depends on a large number of factors, including weight, power requirements, reliability, and accuracy of the over-all system.

The situation regarding communication with a space vehicle is somewhat different from that for tracking. Here the importance of knowing the frequency or transmission time accurately is only that it permits the use of narrowbanding techniques for detecting weak signals. In receiving signals from the vehicle, one can normally use a tracking filter on the ground to obtain a narrow bandwidth. However, for finding very weak signals at the limits of detectability, even running the data through many filters set at slightly different frequencies may not be sufficient since the possibility of obtaining a spurious response is increased. For receiving signals in the vehicle, it is possible to use a narrowband receiver based on a quartz-crystal oscillator and to try many frequencies from the ground simultaneously, but the power which must be radiated is increased. Of course, the use of an atomic standard in the vehicle will be no better than the use of a quartz-crystal device for either receiving or transmitting unless the knowledge of velocity and position are good enough to make use of the additional accuracy. For transponders, the communications situation seems similar to that for the tracking case.

Summarizing, we can say that atomic frequency standards with stabilities of about one part in 10^{11} for periods of months or longer are expected to be available soon for use in earth satellites and space probes. These will make possible a reasonably accurate check of the gravitational frequency shift predicted by the General Theory of Relativity. Atomic standards may also be used in some cases instead of quartz-crystal oscillators or transponders for tracking and communications systems. The desirability of such use for a particular space probe will probably depend on the specific mission assigned to the probe.

Suggested Additional Reading

Most work on frequency standards in recent years has been discussed in the annual Signal Corps Frequency Control Symposium at Asbury Park, N.J.: "Proceedings of the 13th Annual Symposium on Frequency Control, May, 1959" (U.S. Army Signal Research and Development Laboratory, Ft. Monmouth, N.J.). Another source of recent information and references on frequency standards is "Quantum Electronics: A Symposium," Columbia Univ. Press.

Another much more promising method of making a terrestrial check of the gravitational shift has been suggested recently by the discovery of extremely narrow gamma-ray emission lines. See, for example, Mössbauer, R. J., *Z. Physik*, vol. 151, p. 124 (1958); Pound, R. V., and Rebka, G. A., Jr., *Phys. Rev. Lett.*, vol. 3, p. 554 (1959); and Schiffer, J. P., and Marshall, W., *Phys. Rev. Lett.*, vol. 3, p. 556 (1959).

Badessa, R. S., Kent, R. L., and Nowell, J. C., *Phys. Rev. Lett.*, vol. 3, p. 79 (1959).

Ginzburg, V. L., *J. Exper. Theoret. Phys.*, U.S.S.R., vol. 30, p. 213 (1956); (*JETP*, vol. 3, p. 136, 1956.)

Møller, C., *Suppl. Nuovo Cimento*, vol. 6, p. 381 (1957).

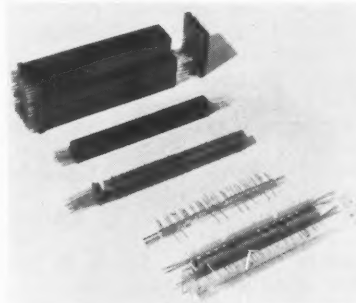
Singer, S. F., *Phys. Rev.*, vol. 104, p. 11 (1956).

Work on proposed experiments using a frequency standard in an earth satellite to measure the gravitational frequency shift is being supported by NASA at MIT, NBS, and Hughes Aircraft Co. ♦♦

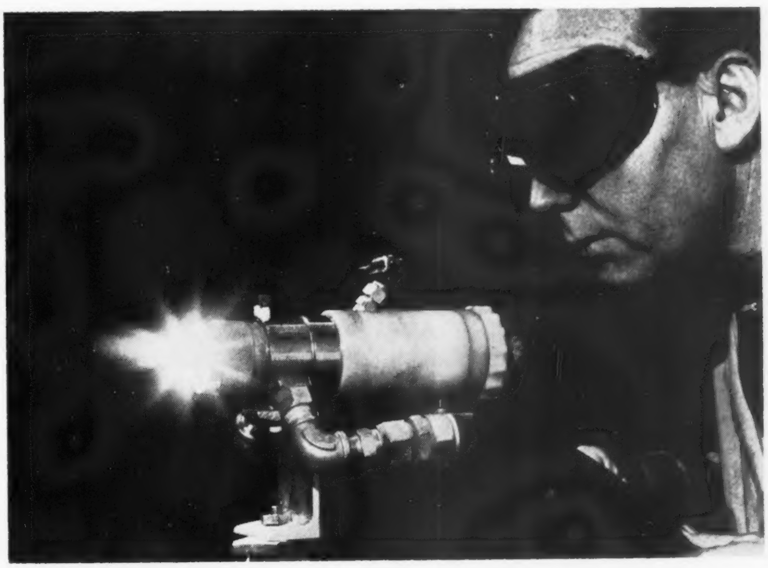
New Engineering Index Available

A new edition of "The Engineering Index," a guide to current worldwide technological literature for 1959, is available for $70, including postage. It includes over 30,000 annotations from more than 1600 technical publications. A catalog outlining the 249 divisions of engineering under which the information is listed is available free from The Engineering Index, Inc., 29 West 39 St., New York 18, N.Y.

Space-Saver



In this "MiniWeld" electronic module, produced by Engineered Electronics Co., Santa Ana, Calif., components are first stacked together like cordwood, and then are sandwiched between two or more Mylar sheets, containing the welded matrix that connects the components and interconnects the circuits. MiniWeld modules are being used in the newest Polaris guidance computer. The technique reduces previous equipment size by 80 percent.



Avco Arcjet Engine

This 30-kw arcjet engine, weighing only $3^1/_2$ lb, has been developed by Avco to propel space vehicles, most likely ones in low orbits. The engine will be able to run for several months with helium or hydrogen as a propellant. It has already generated $^3/_4$-lb thrust for 47 hr running continuously.

In print

Rocket Manual for Amateurs by Capt. Bertrand R. Brinley, Ballantine Books, New York, 382 pp., illustrated. $0.75. Also available hardbound for $6.00.

In his introduction to Captain Brinley's book, Willy Ley says that he is sure that "Rocket Manual for Amateurs" will be controversial, hailed by some and condemned by others. Ley gives several arguments that amateur rocketry is good, even though it admittedly contributes nothing to the state of the art. It does, he contends, contribute much to the student who learns by doing, much as a medical student (Ley's analogy) learns both technique and anatomy by dissecting a corpse's hand, although the experiment adds nothing to medical science.

Much of the manual is good; the safety precautions are the most detailed and, from my experience, the best that I have seen made available to amateurs. But in his zeal to put all amateur rocket firings on a strict "by-the-numbers" basis like that "used by the military," Brinley violates many of his own rules. For instances, he says that a minimum of people should be exposed to any hazard; two men, he says, are sufficient to fuel almost any rocket a teenager might build, but he insists on a third "supervisor" in the "fueling pit" to watch the "fueler and his assistant."

So far as I can see and check, the list of propellant hazards is accurate, but I wonder if it is wiser to tell a 13-year-old that potassium ferrocyanide is a possible propellant but is *very* dangerous, than it is not to let him know the stuff exists until he is old enough to stay away from it.

He presents three rocket designs, complete to the last bolt, nut, and weld, based on "experimental" parameters for zinc and sulfur. One of these, Beta, he claims will go to 20,000 ft; Alpha is supposed to reach 15,000 ft, while the third design is a finless bomb made of an aluminum cigar tube and a CO_2 cartridge stuffed with zinc-sulfur. He claims that the little one is very useful for "testing small quantities of new propellants," though he does not say how he will acquire pressure, temperature, and other data, nor can I see a way to do it. Also, Brinley fails to mention that CO_2 capsules will take very high gas pressures at low temperatures but often crack at higher ones. Presumably he has tested Alpha and Beta before recommending them to amateurs, but he gives no figures other than a vague "It should reach about . . ." altitude prediction.

Some of his technical information is not only wrong, but shows misunderstanding. He says zinc sulfide (the exhaust product of zinc and sulfur) has a "heat of sublimation of 2600 R" which, he says, means that *above* that temperature the compound is a *solid*. This is perhaps a misprint, but his explanations make it seem to be correctly printed. He is also misinformed about American space vehicles, since he says all U. S. rockets have abandoned liquid propellants save for first-stage boosters.

It is hard to take seriously the section on static stands. Of the several designs shown, two have the rockets pulling cables attached to spring scales and will be inaccurate at best and unreliable. A third design uses a hydraulic thrust jack, but the tie-downs would quickly release a rocket with a nozzle only slightly misaligned. The fourth design is the most dangerous thing I have ever seen seriously proposed either to or by amateurs! He suggests that the rocket motor under test be "lashed" (sic) to the rim of a horizontally mounted bicycle wheel. A tachometer is to be fastened to the axle, and by knowing the moment of inertia of the wheel and its final angular velocity, the total impulse of the rocket can be "easily" calculated. The wheel is even mounted without a counterweight.

The section on tracking devices and methods is well done and will in general be a good guide for amateurs who persist in the hobby. The trigonometry is clearly explained in terms of "plug-in" formulas. He fails to point out that titanium tetrachloride, which makes an excellent amateur smoke fluid, is an irritant and is toxic.

The dangers in the book far outweigh the advantages. The "safe" fueling pit still requires hand tamping and mixing of propellants with at least four hands and six eyes exposed. The same is true of most all of his devices; the dangers are hidden but still present.

For an amateur with $5000 to spend and four square miles of land, the launching site seems generally safe enough. Anyone else will read the chapter, say it would be nice to have such a good site, and return to his backyard or an empty lot. Every person on Brinley's site, from range guards to firing crew, will be under cover and behind thick sand-bag walls; the static-testing bay is a copy in sand bag of the Bell Aircraft pits, but the stands themselves are dangerous devices.

Captain Brinley may not have realized that his book will be read by boys and girls 12 to 15 years old who cannot understand the thermodynamics equations given nor the need, which Brinley stresses, for a lot of library research. These children will not even know where to look for information. All they know is that they want to see rockets fly, and that Brinley says that they should. They will ignore the chapters on safety, pound their zinc and sulfur into tubes, go out in the boondocks and proudly fire. And a lot of them will be maimed.

—**Peter D. Zimmerman**
Stanford Univ.

Rocket Data and Sketch Book by B. J. Humphreys Jr., "Rockets," Los Angeles, 31 pp, illustrated. $1.00.

This is a short pamphlet recently published by B. J. Humphreys of the Reaction Research Society. It begins with a facsimile of Dr. Howard Seifert's editorial "Ardent Youth" in the February 1960 *Astronautics* and then presents a collection of sketches and plans of ideas which could be used in amateur rockets. Many of the sketches are crudely drawn without even the use of a ruler or compass; the captions are mostly hand written and full of misspellings.

Of historical interest are the drawings of the RRS's H_2O_2 rocket, reportedly the first such flown in this country. Also interesting is the drawing of their hybrid rocket, a type which the RRS did pioneer. The interior sketches of the hybrid motor are, however, poor; some dimensions—length and chamber diameter—are given, but the critical ones are not, leaving the average amateur to think that they don't matter too much, and that nearly any he uses will work.

Humphrey's also publishes several other booklets and plan sheets on amateur rocketry. These are generally quite well done, although ARS disagrees with his belief that if amateurs

cannot be deterred from working with live propellants, it is better that they be given proven designs such as the Reaction Research Society standard rocket available for seventy-five cents.

—Peter D. Zimmerman

BOOK NOTE

Judging from the tables of contents of **Space** and **Missiles**—two looseleaf, informally printed brochures issued by Government Data Publications, 422 Washington Building, Washington 5, D.C., cost, $20 each, $30 in combination—these volumes, each about 200 pages long, in 8 x 6-in. format, leave no stone unturned in the missile and space field, from the "Human Question" to the "Materials Question" to every project, active or rumored.

In truth, the two volumes do contain a wealth of information culled, it may be surmised, from official press releases, contract bid and award notices, and open-literature reports.

However, you really have to work hard to get this information out of alternately terse and rambling discussions and descriptions, printed closely on a poor grade of paper in sometimes barely readable form, and bound in a most awkward and intractable looseleaf fashion.

The publishers direct these volumes to the industry executive anxious to learn more about the nation's space and missile programs. It is difficult to recommend them unqualifiedly to a man presumably in need of clear, concise, easily readable information.

RECEIVED

Navy Blue Book, Vol. 1, Edited by Tom Compere, (374 pp., Military Publishing Institute, Inc., New York, N.Y., $1.50). Soft cover.

A Course in Applied Mathematics, Vols. 1 & 2 by D. F. Lawden (655 pp., English Universities Press Ltd., 102 Newgate St., London, E. C. 1). Bound together.

Dictionary of Atomic Terminology by Lore Lettenmeyer (298 pp., Philosophical Library, New York, $6).

Dictionary of Aeronautical Engineering by J. L. Nayler (318 pp., Philosophical Library New York, $10).

Foundations of Aerodynamics, 2nd Ed., by A. M. Kuethe and J. D. Schetzer (446 pp., John Wiley, New York, $11.75).

Chemical Fragments as Ultra-Energy Propellants, Abstracts Bulletin No. 4 (57 pp., Aerojet-General Corp., Azusa, Calif.). Paperbound.

Grants for Scientific Research, National Science Foundation (18 pp., National Science Foundation, Washington, D.C.). Paperbound.

◆◆

Saturn Project

(CONTINUED FROM PAGE 27)

evaluation could be made of the Saturn second stage in connection with other DOD rocket programs. As a result of this evaluation, the restriction to use existing hardware was lifted, and a configuration with larger upper-stage diameters—which offered greater mission flexibility and payload—was recommended by ABMA.

Following the proposal of President Eisenhower that ABMA's Development Operations Div. be transferred to NASA, a joint DOD-NASA committee under Abe Silverstein of NASA was formed to select upper stages for the Saturn project. The vehicle recommended by this committee was chosen and has been designated the Saturn C-1. This vehicle, shown on page 26, is satisfactory for early missions and at the same time provides the basis for a building-block technique for advanced vehicles, thus avoiding a dead-end development of stages.

Towering about 185 ft high, this C-1 vehicle design has a second-stage diameter of 220 in. with thrust provided by a cluster of four Pratt & Whitney hydrogen/oxygen engines uprated to 20,000 lb thrust each. The third stage is a 120-in.-diam Centaur with two Pratt & Whitney hydrogen/oxygen engines of nominal 15,000–20,000 lb thrust each.

The C-1 vehicle, necessarily scheduled for a later initial flight date than the vehicle in the original program, now provides high-energy propellant in all the upper stages and large upper-stage diameters, which allow greater mission flexibility and larger payload capability.

The Saturn vehicle also features this country's first large booster designed expressly for space exploration. It is $21^{1}/_{2}$ ft in diam and stands almost 82 ft high from the engine exhaust nozzle to the top of the transition section. This is comparable in height to a nine-story building.

Booster's Makeup

The Saturn booster consists of nine propellant tanks, a center one 105 in. in diam surrounded by eight 70 in. in diam. Liquid oxygen is carried in the center tank and four of the outer tanks. The other four contain RP-1, a kerosene-type fuel. Both tank systems are interconnected to provide equalization of liquid level during propellant-loading and flight operations. The total main-stage propellant capacity of the containers is 750,000 lb. However, it is not necessary to use the full capacity if mission considerations dictate otherwise. The tanks are tied to an eight-legged spider beam at the top and an eight-legged thrust frame assembly at the bottom, to which the engines are mounted.

The eight booster engines are arranged in two square patterns. The four inner engines are rigidly mounted in a 3-deg cant. The outer four are canted at 6 deg and can be gimbaled ±7 deg, thereby controlling the vehicle during boost.

A propellant-flow manifold and pressurization scheme plus an adequate malfunction detection system give the booster a chance to complete its mission even though one engine might develop trouble and have to be shut down.

The first multistage vehicle based on the Saturn booster will be the 185-ft C-1 configuration. Upon completion of C-1 development, a follow-on C-2 vehicle is contemplated. This vehicle could utilize the same basic Saturn booster but we anticipate that a new second stage can be built around the 200,000-lb thrust H_2/O_2 engines presently in the proposal evaluation phase at NASA. A four-stage C-2 with payload would tower about 230 ft from the ground.

Our preliminary design people are now at work on concepts for future development and utilization of Saturn. These include another all-chemical vehicle and possible adaptation of a nuclear third stage for yet another version.

With the first Saturn booster on the test stand, we are looking ahead to these advanced designs, which step by step and year by year will increase the capability of this nation to transport payloads to other planets or to place them in orbit when and where desired.

Net-Weight Capabilities

Without going into details of all the various vehicle configurations and resulting payload performances, here are some net-weight capabilities of Saturn.

The C-1 now being constructed and tested can place approximately 20,000 lb in a 100-mile orbit, 4500 lb in a 22,700-mile (24-hr) orbit, and one ton soft-landed on the moon.

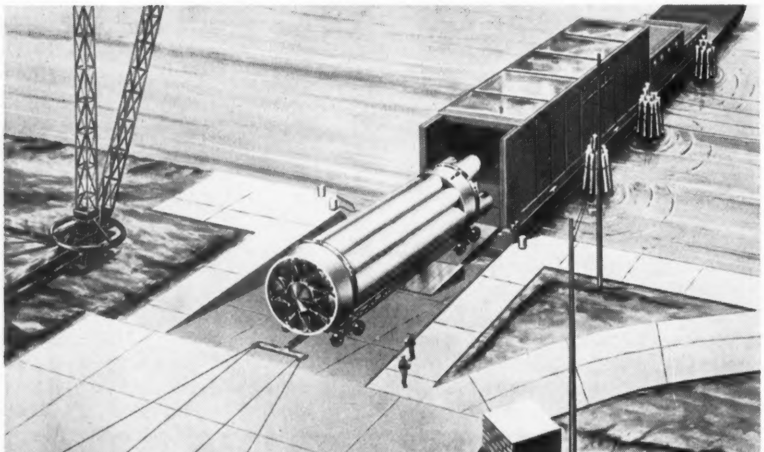
A three-stage C-2 vehicle can approximately double each of the C-1 payloads and the addition of a fourth stage can triple the 24-hr and soft-landing capability.

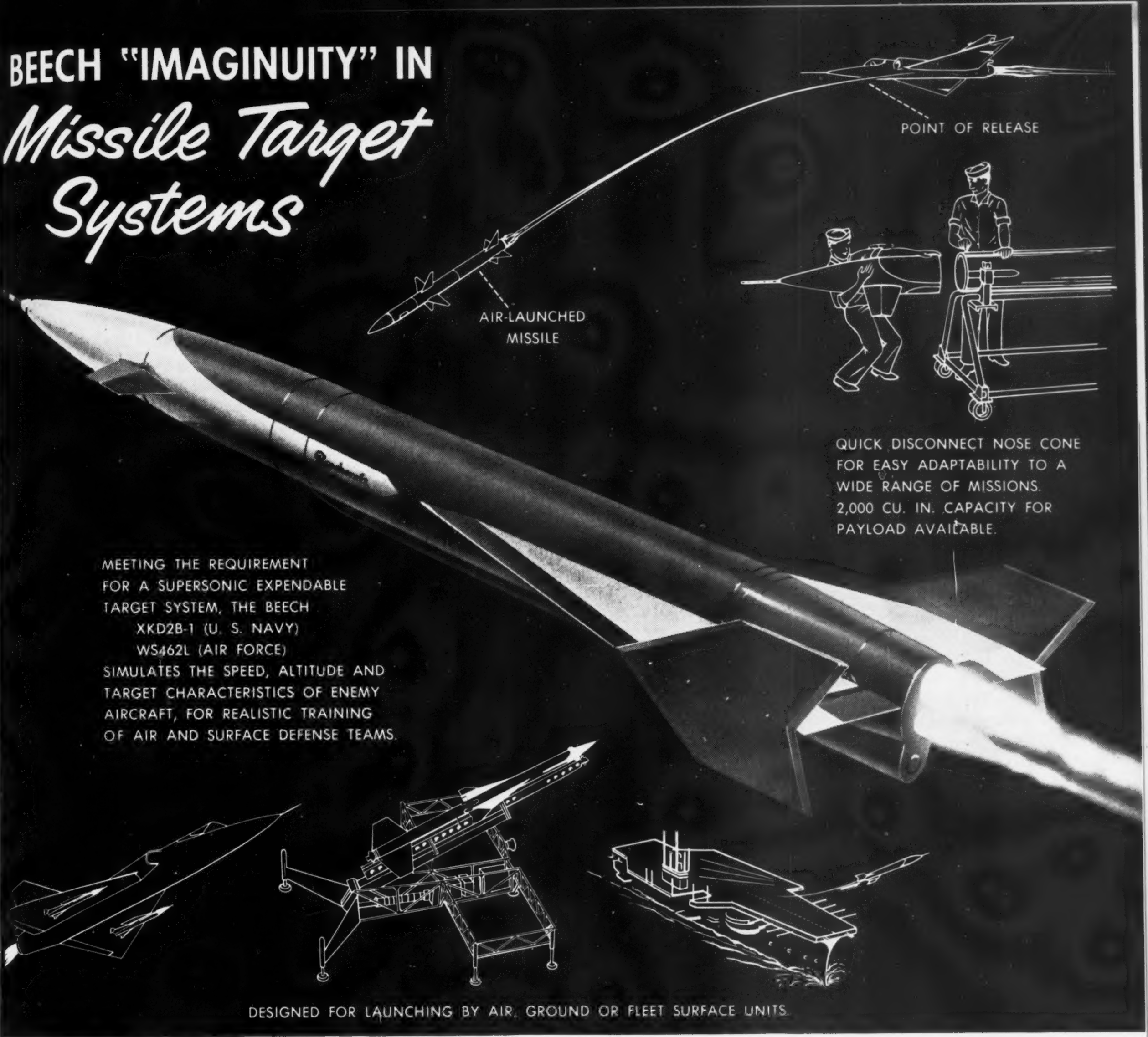
A nuclear stage, if one of appropriate size can be developed, could probably have very high low-orbit capability and boost about 7 tons to a soft lunar landing.

The capabilities shown for escape missions have, of course, been based on direct flights. Now, if we consider an orbital refueling operation in connection with the Saturn single-flight performance, the capability for such missions as a lunar soft landing or a planetary landing can be increased by a factor of 10 or more, depending on the number of earth-orbit refueling flights and the mission requirements.

The Saturn booster, in its final version, will be designed for recovery. On some of the early flights, recovery will be attempted in order to gain valuable operational experience in the recovery of large boosters and to enable the designers to examine components after a flight test. These early attempts will furnish a basis for deter-

Barge Concept





Beech XKD2B-1/WS462L: Winner of Navy/Air Force design competition . . .

Mach 2 target system for realistic training born of Beech cryogenic + airframe experience

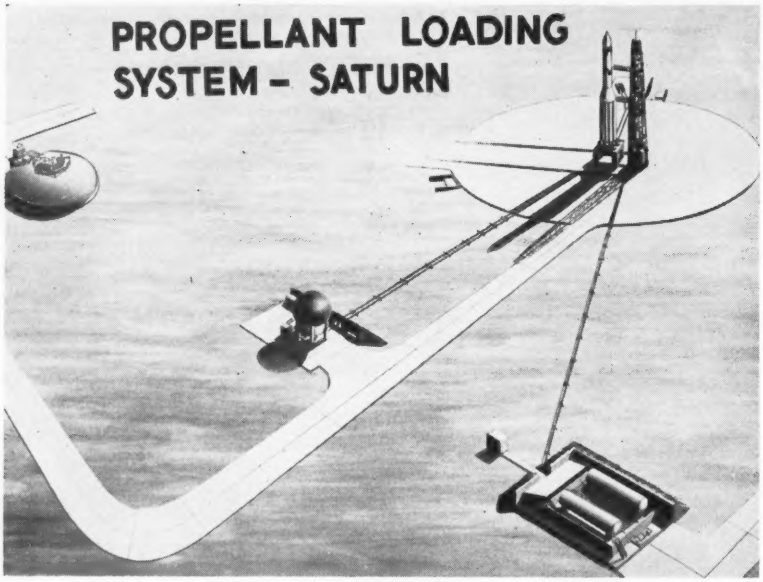
Designed to simulate the speed, altitude and target characteristics of enemy aircraft, the Beech XKD2B-1/WS462L makes possible effective testing of advanced weapons systems and provides realistic training—at low cost—of air, ground and fleet defense units. Into its development has gone more than 6 years of Beech experience in cryogenics, plus over 27 years of airframe know-how. With its pre-programmed guidance system, it operates at altitudes from 1,000 to 70,000 feet and at speeds up to Mach 2. Adaptable for use with Nike, Terrier and Talos launchers, the Beech XKD2B-1 has promising potential for economical development as a missile system. It can carry a substantial payload, to fulfill a wide range of future missions.

Beech Aerospace Division

BEECH AIRCRAFT CORPORATION • WICHITA 1, KANSAS.

Beech Aerospace Division projects include R&D on manned aircraft; missile target and reconnaissance systems; complete missile systems; electronic guidance systems; programs pertaining to liquid hydrogen propellants and cryogenic tankage systems; environmental testing of missile systems and components; and GSE.

May we help you? Write, wire, or phone Contract Administrator, Beech Aircraft Corp., Wichita 1, Kansas—or nearest Area Office.



mining the most desirable recovery procedure for use in later boosters, so that eventually recovered boosters, or at least components, can be reflown. The system now under development is a combination of drag-balloon parachutes and retrorockets. The booster is allowed to re-enter the atmosphere and decelerate to subsonic speed before the recovery sequence is initiated. At about 30,000-ft altitude, a drag balloon is released to trim the booster and a series of parachutes are deployed to stabilize and decelerate it. About 100 ft above the water, the landing rockets fire, reducing the vertical impact velocity to virtually zero.

The method for transporting the Saturn booster is unique in that the frame of the final assembly fixture is used as the main carriage of the transporter. The assembled booster and its support cradle are jacked up as a unit, and two wheel-and-axle assemblies installed. The assembly cradle stays with the booster until it is placed on the static-test or launch pad.

Slow Trip for Booster

Transportation of the booster from Redstone Arsenal to Cape Canaveral will be accomplished by barge, as indicated on page 74, down the Tennessee, Ohio, and Mississippi Rivers to New Orleans. From there an ocean-going tug will tow the barge around the Florida peninsula to Cape Canaveral.

The Saturn launch area will contain initially one launch pad and service structure. Plans call for a second launch complex in the near future to serve as a backup for the R&D program, as well as operational launchings. A launch pedestal with eight arms will support and hold down the vehicle until the liftoff signal is given. The Canaveral pad and gantry are illustrated below.

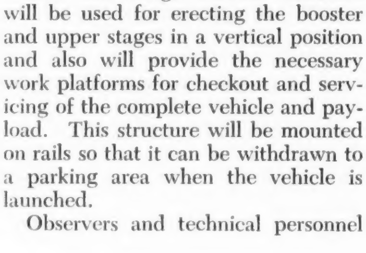
The 310-ft-high service structure will be used for erecting the booster and upper stages in a vertical position and also will provide the necessary work platforms for checkout and servicing of the complete vehicle and payload. This structure will be mounted on rails so that it can be withdrawn to a parking area when the vehicle is launched.

Observers and technical personnel for Saturn launchings will be sheltered in a blockhouse of reinforced concrete covered with sand—basically designed the same as those used now for ICBM launchings.

This is but a brief general description of the Saturn project. During the coming months and years, you will be reading a great deal about this tremendous new space vehicle. In 1961 the initial booster flight with dummy upper stages will be made. The first two-stage developmental flight will be made in 1962, followed by several three-stage flights in 1963. It is our belief that the C-1 Saturn will be operational in 1964. Flight of a C-2 configuration could start immediately after completion of the C-1 research and development phase.

With development of the Saturn space-launch vehicle, the U.S. has taken an important step toward closing the gap that exists between this country and Russia in the race for space-exploration capability. ♦♦

Planned Gantry and Pad at Canaveral



How to Write Better Reports Offered at Penn State Univ.

Engineers and scientists who have trouble writing clear and concise technical reports can avail themselves of a Technical Report Writing Seminar, September 19–30, at The Pennsylvania State Univ. Enrollment will also be open to beginning technical writers and editors—but no professionals please.

The course will include objectives of good report writing, methods for achieving them, mechanics of writing, organization of reports, preparation and use of illustrative and tabular material, and report reproduction.

Information may be obtained from Christian K. Arnold, Associate Professor of Journalism, or from Continuing Education Conference Center, The Pennsylvania State Univ., University Park, Pa.

Complete Polaris, Minuteman Fuel Chamber Tests

Avco Corp.'s Lycoming Div. has completed an extensive program of hydro-tests of small-scale pressure vessels simulating full-scale Polaris and Minuteman fuel chambers. The burst-test program was designed to develop heat-treatment processes which would insure maximum strength for second- and third-stage Minuteman and second-stage Polaris chambers being developed by Lycoming for Aerojet.

People in the news

APPOINTMENTS

ARS National President **Howard S. Seifert** has been named director of the professional development staff of United Technology Corp., where he will be responsible for educational functions, professional society activities, technical communications, and professional planning. Dr. Seifert is also a teaching professor of aeronautical engineering at Stanford Univ.

Richard A. Schmidt, former technical director of the Directorate of Rocket Propulsion and Missiles at Edwards AFB, Calif., and chairman of the ARS Test, Operations, and Support Committee, has been appointed NASA chief of range support, responsible for technical support of launching at the Atlantic and Pacific missile ranges, Wallops Island, and overseas sites. **Hans Hueter** has been appointed project director of NASA's Agena and Centaur programs at Marshall Space Flight Center. **Harry H. Gorman** has joined MSFC's director's staff.

C. C. Miesse, supervisor of combustion and fluids at Armour Research Foundation, and president of the ARS Chicago Section, has been promoted to senior scientist.

Emanuel R. Piore has been elected vice-president for research and engineering at IBM, where he will continue as director of research. Dr. Piore is a member of President Eisenhower's Science Advisory Committee. **Ralph E. Kuehn** has been granted a one year leave of absence from IBM's Federal Systems Div. to serve with the Institute of Defense Analysis in Washington, D.C. The parent company has elevated **Philip W. Jackson** to executive assistant to vice-president and group executive T. V. Learson. Jackson formerly was product development manager for the Advanced Systems Development Div.

W. M. Davidson has been named to head Thiokol's newly formed nuclear unit at Parsipanny, Troy Hills, N.J.

George A. Siegelman has been named director of operations for explosives at Olin Mathieson Chemical Corp.'s Energy Div. **S. J. Wommack** becomes director of research and engineering for the division.

Gordon Harris, public information officer of AOMC, has been appointed supervisor of public information affairs for the Ordnance Corp., with offices at the Pentagon.

Geoffrey Robillard, chief of JPL's Solid Propellant Div., will head the newly formed Propulsion Div., which integrates the Liquid Propulsion and Solid Propellants divisions. **Robert F. Rose** becomes deputy chief; **Donald R. Bartz,** chief, Liquid Propulsion Research Section; **Leonard R. Piasecki,** chief, Solid Propellants Rockets Section; **Anthony Briglio Jr.,** chief, Liquid Propulsion Development Section; **Robert F. Landel,** chief, Solid Propellant Chemistry Section; and **John J. Paulson,** chief, Advanced Propulsion Section.

At Aeronutronic Div. of Ford Motor Co., **Frank Denison** and **Maj. Gen. John S. Mills,** USAF (Ret.), have been named manager and assistant manager, respectively, of the new Lunar Systems Activity set up to manage the division's lunar capsule development program for NASA. **Robert F. Nease** will be in charge of system integration; **Wilbur W. Hawley,** applied mechanics; **Robert E. Heckert,** electronics; and **John E. Richards,** product qualifications. A Lunar Capsule Technical Advisory Committee headed by **Montgomery H. Johnson,** senior staff scientist for Aeronutronic, will provide management support. Committee members include: **Donal B. Duncan,** general operations manager, space technology operations; **Lloyd P. Smith,** general operations manager, research operations; **Samuel B. Batdorf,** manager, product planning for range systems operations; and Frank G. Denison. **James E. Heywood** has joined the division as assistant general operations manager of computer operations.

Col. Ernest A. Pinson has been appointed commander of the former AFCRC Electronics Research and Geophysics Research directorates, recently reorganized as Detachment No. 2 of the new Air Force Research Div.

Paul W. McDaniel, acting director of AEC's Div. of Research, has been appointed director; and **John L. Wilson** becomes manager of AEC's Lockland Aircraft Reactors Operations Office, Cincinnati, Ohio. **Edward Teller,** who has resigned as director of the Livermore Laboratory of the Lawrence Radiation Laboratory, will continue on as an associate director of the lab.

Alvin E. Green, Cornell Aeronautical Laboratory contracts manager, and **John W. Hastie,** coordinator of research, have been named assistant secretaries.

A. Henry Schutte has been appointed to the senior staff of Arthur D. Little, Inc.'s chemical engineering section.

John H. Ferguson has been named to the newly created post of director of contract compliance for Raytheon's Missile Systems Div.

James E. Shepherd has been promoted to manager of the new Sperry Rand Research Center to be built this year in Sudbury, Mass. He formerly was manager of the Electronic Tube Div. at Sperry Gyroscope Co. **Martin J. Crean** has been named director of data processing at the latter company.

Charles R. Burrows, former vice-president, engineering, for Radiation, Inc., has joined Page Communications Engineers, Inc., a subsidiary of Northrop Corp., as vice-president and director of research and development. **Francis M. Ryan** has been elected vice-president and director of engineering at Page.

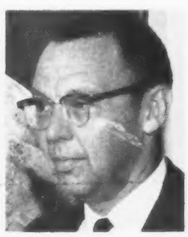
Douglas Aircraft has appointed **Hal M. Thomas** and **Ted J. Gordon,** pro-


Seifert


Schmidt


Miesse


Piore


Denison


Mills


Nelson


Shane


Wolff


Hello


DeGroff


Williams

gram manager and project engineer, respectively, of the Saturn Second-Stage Program. Thomas formerly was program manager of Douglas' Thor Missile Project; Gordon, project engineer, Delta and Able Space Vehicle Programs.

Jean R. Nelson, project engineer at Minneapolis-Honeywell's Aeronautical Div., has joined Winzen Research Inc. as director of engineering.

Presson S. Shane has been elected vice-president of Atlantic Research Corp. He is currently in charge of the company's Solid Propellant Div. and Desomatic Products, Inc., a subsidiary. **Harold W. Gear,** formerly plant manager of the Pine Ridge solid-propellant rocket plant, has been made manager of operations analysis at SPD; **Roger N. Saleeby Jr.,** formerly technical supervisor, SPD, succeeds Gear. **David D. Dudley** has been named technical supervisor of the Pine Ridge Plant; **Warren D. Poling,** supervisor of rocket assembly and testing; and **Paul F. Lumbye,** quality control supervisor.

Hanns S. Wolff has been appointed chief of Republic Aviation's new Electronics Laboratory.

James R. Vine has been named chief of a new computer applications group at Beckman Instruments Systems Div.

Bastian Hello has been appointed program manager for Martin Co.'s rocket booster portion of the AF Dynasoar project. **G. J. Rauschenbach** has been named manager of the company's corporate office at Huntsville, Ala.

Jerome Perlstein and **Edward J. Flaherty** have joined Tenney Engineering, Inc.

H. M. DeGroff has been appointed head of Purdue Univ.'s new School of Aeronautical and Engineering Sciences and director of the Aero-Space Science Laboratory, established for graduate research.

John J. Giba has been appointed manager, Tele-Dynamics Div. of American Bosch Arma Corp.

At General Precision, Inc., **Frank D. Banta** has been named director of program management and **Andrew Georgia,** head of the new Systems Requirements Dept. **J. H. Steele,** will assist Mr. Georgia. At GP's Kearfott Div., **Walter J. Krupick** has been appointed general manager, Gyrodynamics; **William Supina,** manager and chief engineer, Precision Gyro Dept.; and **John J. Daly,** manager and chief engineer, Gyro Reference Dept., Gyrodynamics.

James R. Corcoran Jr. has been appointed assistant to the vice-president of the Ogden Div. of Marquardt Corp.

William B. Gurney has been appointed engineering manager of Chandler Evans Corp., and **Jack O. Nash** has been named chief engineer.

Ernest N. Ljunggren has been promoted to the new position of vice-president for the Minuteman Systems Management Div. for Autonetics Div. of North American Aviation.

William C. Adams has joined Lockheed Electronics Co. as manager of the Computer Systems Div. of Information Technology; **Paul F. Pearce** has been upped to manager, Systems Design, Information Technology Div.

Elmer L. Zimmerman has joined Hughes Aircraft Co.'s nuclear electronics laboratory as head of nuclear circuitry research. In other appointments, **John J. Jarosh** becomes manager of inertial devices and **William L. Parker,** manager of guidance systems, in the Engineering Dept. R&D Laboratories. **Donald F. Davern** has been named project manager of industrial control systems. In the Ground Systems Group, **Kenneth Young Knight** has been named manager of the new Manufacturing Services and Controls Dept.; **David D. Wasson,** manager, industrial dynamics; and **Jose M. Tellez,** manager of the Army Computer Systems Dept.

Arthur Donald Watt has been named to head the Boulder (Colo.) R&D Laboratory Div. of Developmental Engineering Corp. (DECO).

Harold Rapaport has been appointed director of the Advanced Systems Center of ITT's U.S. Defense Group.

Ralph R. O'Dea has been named to assist Richard W. Hodgson, president of Arnoux Corp., in planning and analysis of corporate development.

Harry E. Lockery has been appointed manager of engineering, Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp.

A. S. Ginsburgh has been appointed manager of Aerojet-General's Materials and Fabrication Div. for the Solid Rocket Plant.

Ryan Aeronautical Co. has named **Jules Kravetz,** former director of the Army Signal Corps West Coast R&D Office, director of government relations for its subsidiary Aerolab Development Co.

Jack L. Bowers has been named vice-president of Electronics Systems and Equipment Operations at Avco Corp.'s Crosley Div. Also at the division, **Harland A. Bass** has been appointed chief engineer, data handling, and **Maurice E. Heidbrink,** director of its West Coast office.

Dan Kaufman has been promoted to supervisor of Inorganic Research in the Research Div. of Wyandotte Chemicals Corp. **Saiyid M. Naqvi, Bernard A. Merkl, Donald E. Witt,** and **George Roley** have joined the company's Contract Research Dept.

A. Finley France and **Dixon T. Jarvis** have been promoted to associate director of contracts at Burroughs Corp.'s Defense Contracts Organization.

Robert J. Garon, vice-president of Wyle Laboratories, has been appointed general manager.

Peter P. Wegener has resigned as chief of JPL's Gas Dynamics Div. to accept an appointment as professor of mechanical engineering at Yale University. He was responsible for the design and development of the first hypersonic wind tunnel in the U.S.

Ben W. Badenoch, general manager of the Aero Hydraulics Div. of Vickers Inc., has been elected a vice-president of the company.

David A. Williams has been appointed director of R&D for Standard

Steel Corp.'s new R&D Dept., established to develop new products and processes in the field of cryogenics. **Leon F. Howard** succeeds Williams as director of engineering for the Cambridge Div.

Arthur Marquis has been appointed manager of specialty resistor project, magnetic materials section, Metallurgical Products Dept. of General Electric.

Wolfgang W. Gaertner has joined CBS Laboratories as manager of Electronic Semiconductor R&D.

Saul Feldman has joined Electro-Optical Systems, Inc., as principal scientist in the Fluid Physics Div. He formerly was principal research scientist at Avco-Everett Research Laboratory.

Paul S. Langa has joined Walter Kidde & Co., Inc., as director of industrial relations.

Edward G. Schwarm has been elected president of Applied Dynamics, Inc., a subsidiary of Bowmar Instrument Corp.

C. B. Wilson has been appointed vice-president for program development, Applied Science, Inc. He formerly was corporate systems engineer for Fairchild Engine and Aircraft Corp.

Robert Stein, John Boghosian, Frederick Brugma, and **Richard George** have joined the technical staff of Space Electronics Corp.

James H. Brewster III has been appointed vice-president, operations of Sylvania Electronic Systems.

Richard W. Soshea has joined Rheem Semiconductor Corp.'s R&D Dept.

Alan G. Stanley has been promoted to assistant director of research at General Transistor Corp.

Peter J. Van Zandvoord will head a new consulting service on high-speed photo instrumentation within the Camera Products Dept. of Beckman & Whitley, Inc.

HONORS

Abe Silverstein, director of NASA's Space Flight Programs, has been awarded the honorary Doctor of Humane Letters degree by Yeshiva University.

Thomas R. O'Meara, Hughes Aircraft Co. electrical engineer, has received IRE's first Dr. William G. Tuller Memorial award "in recognition of the most outstanding technical paper dealing with electrical component parts published in professional journals in 1959." ♦♦

Observation Satellites

(CONTINUED FROM PAGE 29)

width of about 4.25 mc/sec. A communication link of the same bandwidth in a satellite is a reasonable technical and engineering goal. A simple equivalence from which other calculations are easily made can now be constructed.

Considering the approximate nature of the formulas already noted, the underlying assumptions, and the fact that not all the channel width can be devoted to handling this information (effective bandwidth is always less than the nominal value because of control, sequencing, and other operating information which must be transmitted), it is entirely appropriate to round off the results of this calculation into an easily remembered statement: *Transmission of the information contained in one 9 x 9-in. photograph, at 100 lines/mm resolution, on a channel of 4.25 mc/sec bandwidth, requires about 30 min.*

Another and highly instructive way of looking at the limits or constraints on the amount of information which a satellite can send to earth is to calculate what can be transmitted if this channel width is used for 24 hr—thus ignoring the very real and dominant factor that a given site can receive from a 300-mile satellite for a period of only 10 min per pass, and that this pass must be directly over the ground station. This assumption is equivalent to imagining that the satellite, at all times, in all orbits, is communicating with some ground station. Transmitting for 24 hr, the satellite can send back the equivalent of 48 high-resolution 9 x 9-in. photographs as described previously. These numbers may be used to make estimates for different film sizes and resolution numbers.

For example, suppose one wishes to compare the information capacity of two systems, A and B, where A produces 15 ft of $2^1/_4$-in.-wide (70-mm) film at 100 lines/mm and B produces 500 ft of $4^1/_2$-in.-wide film at but 40 lines/mm. We would have

$$\frac{A}{B} = \frac{(15)\ (2^1/_4)\ (100)^2}{500 \times (4^1/_2)\ (40)^2} = \frac{1}{10.7}$$

Thus system B would contain more than 10 times as much information as system A. Of course, consideration of ground resolution and real content, from the photo-interpreter's view, are excluded here.

It is essentially simple and straightforward to sketch out the characteristics of satellite systems that would collect in one day many times more data than could be transmitted by video link. One example will suffice. Consider a 36-in. focal-length system (a median example, since, for mapping, much shorter lenses could be used; for extremely detailed observation, much longer lenses) which covers, either through single-lens panoramic techniques or through a conventional multiple-camera installation, an angle of about 90 deg from about 150-mile altitude.

It may be readily calculated that such a system could cover about 6,000,000 sq mi per day, and consume at least 3000 ft of 9-in.-wide film. If a resolution level of 100 lines/mm is obtained, this amount of information would require about three months to transmit, transmitting 24 hr per day! The system described would seem to be within the state of the art. Systems of much larger capacity are conceivable and may prove desirable.

Video Can't Keep Up

There are important cases, then, where a video link cannot transmit information as fast as it can acquire it. Small improvements in transmission systems, such as increasing the number of ground stations, are minuscule attempts to cope with an inherent impotence which misses requirements by factors which could be as high as a thousand or more. This is one of the main reasons for physical recovery of the film payload, and furnishes further evidence that extreme precision in the formulation of the information transmission problem is not warranted. Arguments about factors of 30 percent or so in the formula for bits or in the formula for channel capacity are microscopic in a situation where an alternative system has a capacity 1000 times greater.

An observer aboard a satellite could, in principle, study a large amount of data and transmit selected portions of the data, or, perhaps, selected remarks about the data. This form of data processing would greatly reduce the complexity of communication facilities (from the satellite to earth), but obviously raises new problems concerned with providing an environment for the man. The weight of the man and the much greater weight of his environment must be deducted from the total payload. Hence, the oversimplified comparison, for a given weight on orbit, is between a man plus a small camera, and a much larger, unmanned camera.

It is not the intention of this paper to argue either the advantages or the disadvantages of the manned observation satellite. It seems fairly clear, however, leaving a discussion of usefulness aside, that manned observation satellites will not be available as early as unmanned observation satellites.

Physical recovery of a film payload

such as that described in the last example—3000 ft of 9-in.-wide film—produces a given amount of information faster than it can be delivered by video link.

This last remark is deliberately provocative, for it exposes the nature of some potentially fallacious comparisons between recovery and video transmission systems. Consider the last example. It is clear that if a film recovery satellite and a video talkback satellite were launched together, the first data to be returned would come from the talkback satellite. However, the delivery rate would be small.

None of the data from the satellite utilizing physical recovery can be in hand until all of it is recovered. The delay to the first data is therefore large, but the production rate after this is tremendous. These remarks do not suggest dominance of either system. What is suggested is that the two systems can, and likely should, perform different kinds of tasks.

Twenty-Four Hour Satellite

The satellite whose period is exactly that of the earth—commonly called the 24-hr satellite—is a topic of wide interest and speculation, and is of special interest in any discussion of observation satellites.

This vehicle would appear to remain at the same point in space, and from it huge areas of the earth could be put under constant surveillance, limited to some extent, with respect to the satellite's visual sensors, only by darkness and clouds. The observation potential seems enormously attractive.

Several points need to be made. The actual period of the satellite would be equal to the sidereal, and not the solar, day. This is 23^h, 56^m, 4091^s, and not 24 hr, and is the same as the earth's rotation period. The 24-hr day differs from this because of the earth's advance in its orbit and the consequent extra rotation necessary to bring the sun back into the meridian plane. Further, the satellite must be moving in an easterly direction as the earth does, at a height of some 22,240 miles above the earth (5.61 earth radii) in an orbital plane coincident with the earth's equatorial plane.

Consider what can be seen from such a satellite. It may be readily shown that from this position the maximum latitude that can be seen, with line of sight tangent at that point, is about 81.3 deg (north or south). However, atmospheric attenuation, requirements for perspective, image contrast, etc. set a practical limit of about 5 deg less than this, reducing the area capable of being observed to what lies within the latitudes 76.3 deg N and S. The 5-deg limit may be considered a minimum useful visual angle of attack. The area falling within these latitude limits, and visible from the satellite viewpoint, can be shown to constitute about 38.2 percent of the earth's surface, or approximately 75 million sq mi.

Inclining the orbit plane slightly, say 10 deg, will result in the satellite's tracing a "figure eight" pattern over the ground, and will remove the blind spots north and south of 76 deg latitude. Clearly, when the satellite orbit is inclined, the satellite position will wander off the meridian, i.e., not remain directly above a given longitude. The maximum departure from the meridian, for an orbital inclination of the order of 30 deg, is about 5 deg. For a 10 deg orbital inclination, this maximum departure from the assigned meridian is 1 deg. These points are shown in the illustrations on page 29, taken from J. H. Hutcheson's paper on "Earth-Period Satellites."

Extended discussion of factors which might affect the positioning of such a satellite, especially those inevitable errors and natural perturbations which will cause departures from perfect circularity at the assigned altitude, are out of place in this necessarily brief discussion. These effects are real, and are discussed more fully in the same paper. Preliminary assessment and evaluation of these factors are necessary to determine whether there are reasons which would preclude placing a satellite in such an orbit. The answer seems to be that there are none. This is not to deny that there may be considerable engineering and technical difficulties; on the other hand, all complex projects have such problems in common.

Interest in the 24-hr satellite stems mainly from the intuitive notion that it would be useful for observation of the earth and its cloud patterns. Of course, there may be other potential uses, such as communication, listening, and the like, but observation is the most readily appreciated use of a satellite.

On the other hand, it is not altogether obvious that useful observation can be made from such a great distance. A preliminary examination of the optical and photographic problems involved should therefore be useful in thinking about the role of such satellites.

The drawing on page 28 illustrates the geometry of viewing a point on the earth at 45-deg latitude from the orbital altitude of 22,240 miles. The slant range to this point is 23,560 miles, and the angle δ (which may be called the visual angle of attack) is 38.17 deg.

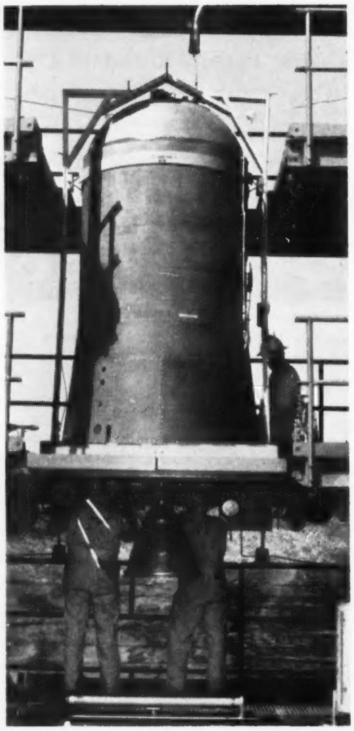
Let us assume we desire to resolve 100 ft, in the x direction, on the ground (perpendicular to the line of sight, and hence perpendicular to the plane of the drawing). It may be readily calculated that 100 ft subtends an angle of only 8.04×10^{-7} radian, or approximately 0.166 sec of arc. By way of illustration, a $^1/_4$-in.-diam pencil subtends this same angle at about 5 miles! The Dawes criterion (developed under conditions of perfect optics, and entailing the visual examination of two bright point images, such as stars, and hence not entirely applicable to this problem) gives the theoretical resolution in seconds of arc as a function of lens diameter in inches as

$$\text{Resolution, in seconds of arc} = \frac{4.5}{\text{Diameter of lens, in inches}}$$

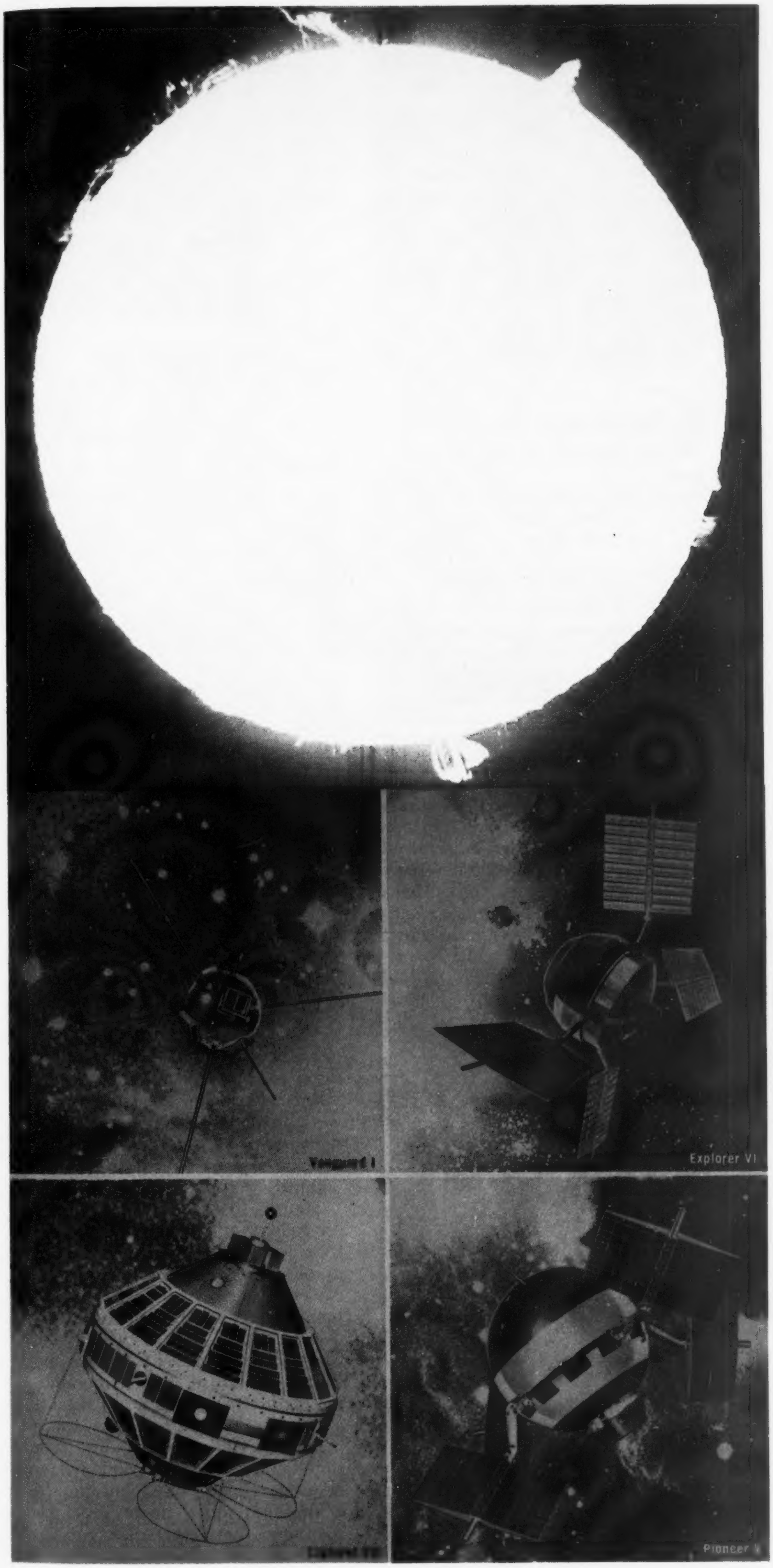
From this formula, required lens diameter for the case under discussion is about 27 in.

Because of projective effects, 100 ft in the y direction (along the line of

Able-Star Upper Stage



Technicians check the Able-Star upper-stage rocket that saw its first use helping to put the Transit satellite in orbit April 13. Developed by Aerojet-General for the Air Force, Able-Star features a rather precise guidance system for an upper stage and a restart engine.


Vanguard I
Explorer VI
Pioneer V

sight, and in a direction perpendicular to the previous case) subtends a smaller angle (by a factor of 1/sin 38.17° = 1.62 times), and hence requires optics about 44 in. in diam.

Now, the required resolution called for in this example—about 0.1 sec of arc—is substantially better than that achieved routinely in astronomical observation such as those at Mt. Wilson and Mt. Palomar. Visitors to these installations cannot help being impressed with the engineering and scientific accomplishment represented there. Yet these observatories have difficulties in consistently achieving resolution better than 1 sec of arc, despite the 100- and 200-in.-diam optical systems in use.

One second of arc represents about a mile at the distance of the moon. However, the troubles that affect earthbound observatories—that is, those which limit resolution and degrade it to much less than the figures given by theoretical limits and optical performance—are, in large part, chargeable to the atmosphere. Temperature gradients, wind shears, atmospheric inhomogeneities—all degrade resolution. The optical system in the 24-hr satellite and the satellite itself will encounter many problems, but not the problem of "seeing."

Specification of lens diameter alone is insufficient to describe the required optical system. This system could be used as a telescope, if an observer were aboard, or as a camera using either photographic or television techniques.

Assume, for example, that photographic film will be used, and that a combined film-lens resolution level of 100 lines/mm is achieved on the film. This performance far exceeds the standards of skilled amateur or professional photographers, but is within the present state of the art, assuming new emulsions, the best optical designs, vibration-free systems, and the best camera design practice.

Because of interaction effects, this performance implies that the resolution capabilities of both the lens and the film receptor must separately be considerably greater than the required final resolution number. These capabilities are, by now, fairly well understood by workers in the field.

Lens Performance

The relation between the theoretical performance of a lens and the resolution it alone can deliver in its focal plane (no film), when examined visually, is usually given by: Resolution in lines/millimeter $= \dfrac{1500}{f/\text{number}}$

For the case under discussion—achieving 100 lines/mm on film—we may assume the lens must have a resolution capability of its own of at least twice this amount, or 200 lines/mm.

From the simple formula above, it appears that the lens speed must be at least $f/8$. There are new film emulsions which have demonstrated a capability of resolving several hundred lines per millimeter. One of these could be used; on the other hand, there is a trade between film speed or sensitivity and resolution. Hence the use of high-resolution film will require faster optics than $f/8$, in order to permit useful short exposure times.

From the lens diameters derived in an earlier section of this series, 27 and 44 in., it might be argued that the larger number should be used. As it turns out, this number is not large enough. Suppose that a 40-in.-diam system, at $f/8$, is chosen. This yields a focal length of 320 in. The scale number, S_y, for objects lying in the y direction is found to be 7,550,000. Thus the image size of a 100-ft object is given by

$$\text{Image size} = \frac{\text{Object size}}{\text{Scale number}} = \frac{100\text{ ft}}{7.55 \times 10^6}$$

This calculation, upon conversion to millimeters, yields an image size of 0.004 mm = 1/250 mm which is well below the obtainable resolution. The only way to take account of the loss in resolution imposed on the system by employing film (which of necessity has a finite resolution capability) is to increase lens diameter, while keeping speed or $f/$ number the same. Thus we are led to a requirement for lens diameters approaching 8 ft with focal lengths of about 64 ft. Such optics are huge even by terrestrial standards, since this is approximately the size of the Mt. Wilson telescope. It may be well to keep the result of this calculation in mind when thinking about observing the earth from the moon, which is about 10 times farther from the earth than the 24-hr satellite.

Occasionally, one hears discussions of the possibility of resolving 20 ft on earth from an observatory on the moon. Note that this requires resolution 5 times better from distances 10 times as great as those in the example just calculated. Thus, to resolve 20 ft on earth in photographs from the moon will require a camera system working at its theoretical resolution limits, with an aperture about 400 ft in diam and a focal length of at least 3200 ft!

Suppose that the much more modest camera of 8-ft aperture and 64-ft focal length were used to take photographs 4 x 5 in. (the common press camera film size) from the 24-hr position. The total field of view of the camera would be less than 0.5 deg. The area covered by this 64-ft focal-length camera, if it were pointed at the earth at 45-deg latitude, would be about 152 by 197 miles, or approximately 30,000 sq mi. This is only slightly less than the combined area of Connecticut, Massachusetts, New Hampshire, and Vermont, or of Denmark and the Netherlands.

Clearly, the achievement of ground

Far-Infrared Scanner

Designed and built by Martin-Baltimore, this new 50-lb gyroscopic Far-Infrared Scanner, adaptable for anti-ICBM missile guidance or interplanetary navigation, permits detection of objects having very low temperature, such as the outer surface of a satellite.

All the components—mirrors, detectors, and detector amplifier—can be rotated as a unit, permitting the device to remain stable during spins or turns of its carrier.

The scanner could sense heat from an attacking ICBM, distinguish this heat from bogus heat or flare decoys, and guide an anti-missile missile to target intercept by means of a sensitive electromechanical system.

In space navigation, it could be used to detect infrared rays from stars, planets, or satellites, and could help guide a space probe to its destination.

Engineer's face is reflected in the Scanner's primary mirror, surrounding the unit's detectors and preamplifiers. Secondary mirror extends on tripods in front of the Scanner.

resolution such as that calculated above would be an engineering and scientific triumph of the first magnitude. Requirements for stability of the camera system, given any reasonable exposure time, such as 1/100 sec, are severe. Angular motions which tend to blur the photograph must be kept to, say, 0.05 sec of arc during the exposure time. This is formidable indeed.

Other problems, such as communication with or from this satellite, handling of the pictorial or visual information, use of other sensors, such as infrared systems for detection of missile firings, will simply be noted.

The properties of noncircular 24-hr orbits are not easily visualized. The general effect is to distort the lobes of the "figure-eight" pattern shown on page 29. The Hutcheson paper provides an analysis of the effects of eccentric orbits and an appreciation of their usefulness. Clearly, it should be possible, by proper shaping of the orbit, variously to apportion and weigh the positions and dwell-time of the satellite's subpoint. For various problems involving communication, observation, or both, it might be desirable to have the satellite spend most of its time over a given area of interest. Use of properly chosen orbits, i.e., considering varying eccentricity, orbital inclination, and apogee position, can produce quite a broad spectrum of satellite observational-communication characteristics. The Hutcheson article includes a detailed analysis of these orbits.

Meteorological Observation

One application of the 24-hr satellite will not require the huge optical systems described above. The possibility of conducting meteorological observation from the 24-hr satellite is especially intriguing because of the relatively low definition or ground resolution required and the enormous view afforded from the position of this satellite. As will be noted later in this series, no one in the U.S. has examined enough extreme (rocket or satellite) altitude cloud photographs, taken under enough different circumstances and times, to permit building a firm photo-interpretation system, with its keys, libraries, and techniques.

Study of the history and development of aerial photographic interpretation seems to demonstrate that as the art has developed, the skilled interpreter tends to use photographs at scale numbers which would have been rejected in the past. This simple and important fact makes discussion of satellite observation, of whatever kind, a reasonable and viable topic. Photo-interpreters active during World War II have been known to exhibit shock and incredulity at (and therefore to dismiss) the notion that photographs taken from altitudes of hundreds of miles might ever be useful.

The Largest Forged

These H-11 tool-steel blanks for solid rocket end-closures were closed-die forged by the Wyman-Gordon Co. by a single squeeze of a 50,000-ton press. The largest ever forged of H-11 steel, the blanks measure 40 in. in diam and weigh about 840 lb each.

It may therefore be expected, with considerable confidence, that as photo interpreters become accustomed to looking at cloud photographs, their resolution requirements for *a given level of recognizability will be relaxed.*

This is not to remove the sensible requirement for occasional small-area, high-definition photography, to verify or to identify larger cloud areas of the same texture and composition. Further, other special meteorological phenomena might well demand closer and more detailed looks than those demanded by routine weather observation.

For the following illustrative example, let us assume that a ground resolution of 2500 ft will satisfy the resolution requirement for cloud photography. Taking account of the curvature of the earth and proceeding from the calculations performed earlier in this section, it may be shown that, based on achieving 100 lines/mm on film, an optical system of say 2- or 3-ft focal length will do. Significant improvements in obtainable resolution would permit reduction of the required camera size.

Because the satellite is so far from the earth, a 2-ft-focal-length camera, taking standard 9 x 9-in. format photographs, will cover all the earth visible from that position. It seems reasonable that several properly spaced 24-hr satellites could cover the entire earth. If no more than four photographs per day are taken from one of these satellites, and then processed and transmitted to earth by video link, it can be shown that this requires a bandwidth of 6 mc/sec for a total time of 90 min to send back all four photos. If transmission can be increased to 2 hr per photo—which seems reasonable and proper, trading bandwidths for time—it could take somewhat under 1-mc/sec bandwidth.

Transmission would be greatly simplified by having ground stations within line of sight of the satellite continuously, thus eliminating the difficulties encountered with low-altitude (e.g., 300-mile) satellites—finding the satellite, locking on to it, and reading for no more than, say, 10 min.

The low rate of film consumption—say, four photographs per day—yields a year's operation on somewhat more than 1000 ft of film, which for the $9^{1}/_{2}$-in. width required, and use of available thin-base film, would weigh less than 25 lb.

If progress in the film and camera art arrives at the point where resolutions of 200 lines/mm are available for use in this satellite, the film size needed would be about the same as the 4 x 5-in. film used by news photographers, with the camera focal length going to 12 in. In this case, film widths would be cut in half over the example calculated previously, film length for a year's operation would decrease to 500 ft, and film weight for a year's operation would be about 6 lb!

In principle, television systems could be used for meteorological or weather observation from the 24-hr satellite position. There are obvious, fundamental, and attractive advantages to TV systems when compared with photographic systems which consume non-reusable film. On the other hand, TV-tube image format areas and their resolution are both much less than in the photographic example given above, requiring both scanning mechanisms and focal lengths perhaps 10 times greater than what would be required for very-high-resolution film systems.

—Amrom H. Katz

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♦♦

Part 4 in this series, to appear next month, will cover the application of observation satellites to scientific problems and the use of such satellites in mapping and geodesy.

ASTRONAUTICS Data Sheet — *Propellants*

Compiled by Stanley Sarner, *Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati 15, Ohio*

MONOMETHYL HYDRAZINE (MMH)—($CH_3N_2H_3$)

MMH is a clear, colorless liquid with an odor similar to that of lower aliphatic amines. It can be stored safely, without deterioration, for extended periods of time and over a wide range of temperatures if the air supply is limited. It is not sensitive to impact or friction and is more stable than hydrazine under conditions of mild heating, but is similar to hydrazine in its sensitivity to catalytic oxidation. It is somewhat more viscous, however, than UDMH.

Hazards

MMH is more toxic than hydrazine. The LC50 (the concentration which kills 50 percent of a group of 10 or more test animals) is 74 ppm as compared to 570 ppm for hydrazine. The LD50 (the dose administered intravenously which kills 50 percent of a group of 10 or more test animals) is 14 mg/kg of body weight as compared to 34 mg/kg for hydrazine. It is similar to hydrazine in that it is a respiratory irritant and convulsant, and it also has been found to produce hemolysis and elevated temperatures in dogs. It is felt that a maximum allowable concentration of 0.1 to 0.5 ppm would be adequate since the tentative hydrazine MAC (0.5 to 1.0 ppm) is probably conservative.

Materials for Handling

MMH is very similar to hydrazine in its compatibility with metals. Stainless steels (types 347, 304, 4130) and aluminum (54S, 6061-SO) may be used. Copper and its alloys, and rust, should be avoided due to the possibility of catalyzing decomposition.

MMH attacks organic materials, such as elastomers, more severely than hydrazine. Suitable nonmetals include Teflon, Kel-F, and polyethylene.

Cost and Availability

MMH is not in wide production but could be expanded using the modified Raschig process. It is expected that the price would be about the same as hydrazine (about \$3.00/lb) if made in large quantities.

Theoretical Performance of MMH*

Oxidizer	Specific Impulse (sec) Frozen Flow	Specific Impulse (sec) Equilibrium Flow	Chamber Temperature** (Deg K)
O_2	298	312	3528
H_2O_2 (95%)	274	279	2900
RFNA	272	279	3172
N_2O_4	278	288	3361
ClF_3	274	287	3803

* P_c = 1000 psia; P_e = 14.7 psia; Optimum O/F ratio.

** Corresponds to equilibrium flow impulse.

Physical Properties of MMH

Boiling Point	87.5 C	189.5 F
Freezing Point	−52.4 C	−62.3 F
Density at −50 C (−58 F)	0.938 g/cm³	58.6 lb/ft³
at 0 C (32F)	0.897 g/cm³	56.0 lb/ft³
at 25 C (77 F)	0.874 g/cm³	54.6 lb/ft³
Viscosity at −55 C (−67 F)	19.0 centipoises	—
at 25 C (77 F)	0.78 centipoises	—
Vapor Pressure at 25 C (77 F)	0.0653 atm	0.960 psia
at 70 C (158 F)	0.526 atm	7.73 psia

Chemical Properties of MMH

Heat of Formation (liquid) at 25 C	+12.7 kcal/mole
Heat of Vaporization at 25 C	9.648 kcal/mole
Heat of Fusion at Freezing Point	2.491 kcal/mole
Heat Capacity at 25 C	32.25 cal/mole-C
Maximum Allowable Concentration (In Air for 8-hr day)	0.1–0.5 ppm

CUT ALONG THIS LINE

Missile market

By **Jerome M. Pustilnik,** *Financial Editor*

*Index compiled June 1955

	June 1960	May 1960	% Change	June 1959	% Change
Dow-Jones Industrials	626	602	+ 3.9	644	− 2.8
Missile Index	1024	888	+15.3	1093	−6.3

WHAT has happened to such leading missile securities as Boeing, Douglas, and General Dynamics? And why have they fared so poorly while other missile securities, particularly electronic stocks, have done so well? This divergency is puzzling.

The explanation, we believe, lies in the transition or, more specifically, the little understood nature of the transition through which the industry has been going. Switching from manufacturing aircraft to missiles requires more than a shifting of gears—and machine tools. Concepts of obtaining contracts are radically altered. Lead time for these contracts (and transition itself) must be measured in years, not months. And companies in the industry have been moving in this direction at varying rates.

In a recent speech before the New York Society of Security Analysts, George M. Bunker, Chairman of the Board of The Martin Co., graphically described these factors.

"Let us begin with the customer, as you must in all business," he said. And "contrary to the general impression, in the defense business, the customer is not simply the Dept. of Defense, the Air Force, the Army, or the Navy. You can't simply say that the Air Force, Army, or Navy wants this or that weapon system. This cannot be done until the system itself has reached maturity and there is an upcheck in terms of sizeable money allocations to buy in operational quantities, and that is too late. That usually is about five years too late for the defense contractor who is looking for new business. It is five years too late to have any real hope of participating in a given program.

"The customer I am speaking of is one of the military services, planning in terms of fulfilling one of its missions and searching for the means to accomplish it in the future. The first step is the definition of the requirement. This is almost always time consuming, and it encompasses the actions of all of the segments of a particular military service. At this point, where the requirement is defined, it is none too early—and sometimes even then it is already too late—for a defense contractor to be aware that a requirement is about to be formally established. Ideally, the contractor should have long since been aware of the requirement. He should have been searching for solution in terms of what can be accomplished in the timespan available, in terms of the state of the technical arts, in terms of scientific development and, of course, in terms of the economics of the matter—that is, whether we as a country can afford a solution to the military problem. He should have been working, either under paid studies, which in some cases are available, or on the basis of his own funds if they are not. Furthermore, assuming that a contractor is well informed and also that he is well qualified by virtue of his research and development work, he needs at this very early date to make certain hard choices. Many of these so-called requirements never mature into weapons systems, either because the requirement changes or its solution is neither feasible nor economical.

"In addition, the contractor himself is limited, not only by his funds, but by the limitations on the number of technical and scientific people that he has available. He cannot pursue all of the possibilities, and therefore he has to make his choices, and he must make them very far in advance. Little information is available on upcoming military requirements for obvious security reasons. Nor is there available to the public or to the analysts any information on the areas in which individual contractors have chosen to concentrate their development efforts, because at this early time security requirements also keep the information under cover.

"Thus, it is fairly apparent that a very essential analytical ingredient, i.e., information on the outlook for the business in the long term, is deeply obscured. And, of course, this difference between the defense industries and others, such as automobiles, steel, oils or chemicals, is too obvious to be belabored.

"The recent and dramatic shift in this industry, from aircraft to missiles and electronics is well known to you all. I daresay, however, that only now is the investing public reevaluating the individual defense contractors. I want to suggest that the reevaluation is tak-

ing place in terms of present operations —that is, the immediate present, sales, earnings, and backlog—and point out that this is not the most realistic basis. The realistic basis would be to think in terms of the future prospects, and this depends upon information and data that are largely obscured.

"Next in the process of seeking a government contract comes an industry competition and the period of evaluation of the submitted proposals. Today, an increasing number of companies are entering these competitions, and they include many that were not earlier identified with the defense efforts. Thus, the competition is keener than heretofore, and a necessity for early and thorough knowhow is even more important.

"When the period of competition passes and a contractor is selected, then comes the research and development period of from one to two or even three years, and the program develops to the stage where large sums of money are required. Here we get into the time period when more information is available and some fairly definite data can be had. Scraps of intelligence come from budget hearings, from contractors' announcements, military press releases, and the like, and from this some judgment can be formed. Particularly when very substantial sums are required, or where rival systems exist, each with their own protagonists, is the available information likely to be more detailed."

This column believes too much emphasis cannot be placed upon the prolonged time schedule through which an aircraft company must pass before it becomes a missile company. Too much emphasis also cannot be placed upon the different stages in this cycle which individual companies have reached, and the divergent behavior of specific securities within our industry.

In our opinion, companies which have actually completed their transition or come close to doing so are Ryan, Northrop, Lockheed, North American, and Martin, in that ascending order. ♦♦

Unclassified ASTIA Index Available

A nine-volume comprehensive index of 40,000 unclassified documents published by the Armed Services Technical Information Agency has been released for general use. The 2647-page "subject index to unclassified ASTIA documents" is available for $30, as PB 151567, from Office of Technical Services, Dept. of Commerce, Washington 25, D.C.

International Scene

(CONTINUED FROM PAGE 18)

proved the methods of calculation for the shell-model nuclei and proved that the theory of universal V-A Fermi weak interaction is superior to all the other types (including the Yukawa type) of theories of universal weak interaction." At the Joint Institute for Nuclear Research at Dubno in the U.S.S.R., Chinese and Soviet scientific workers, under the guidance of Soviet scientists, have in a comparatively systematic way studied the problem of how to determine experimentally the spin and relative parities of various particles.

* * *

In 10 years, the number of scientific research institutions and of scientific workers has grown tremendously, Du notes. At the end of 1958, there were already more than 840 research institutions for the natural and technical sciences and more than 32,000 research workers, representing increases of 20 and 50 times the "pre-liberation" figures, respectively.

During the same period, scientific research organizations have also been strengthened. The total number of publications in the collections of the main library of Academia Sinica and the libraries of its various institutes has increased from 630,000 volumes at the time of the "liberation" to more than 6,000,000 volumes today. The main library has made arrangements for exchanging publications with 1290 institutions in 56 countries. Between the beginning of 1950 and September 1959, the Science Press, publishing house of Academia Sinica, published a total of 2050 book titles and about 2700 periodical issues, containing in all 661,000,000 words and aggregating 30,800,000 copies. In addition, the Institute of Scientific and Technical Information has been established and at present publishes 89 kinds of periodical publications to disseminate scientific and technical information, and exchanges scientific documents with countries throughout the world. ♦♦

1960 Tsiolkovskii Gold Medal Competition Requirements

The Presidium of the Academy of Sciences U.S.S.R. is conducting a 1960 competition for the K. E. Tsiolkovskii Gold Medal. This medal is awarded to Soviet and foreign scientists for original contributions of great significance in the development of astronautics.

Papers will be accepted covering work in 1957–59, and may be submitted by scientific societies, scientific research institutes, or individual investigators.

Papers must be submitted to the Commission on Interplanetary Travel of the Academy of Sciences U.S.S.R. (Moscow, G-242, B. Gruzinskaya 10, Room 132). A paper should be headed, "For Competition for the K. E. Tsiolkovskii Medal" and must be submitted in triplicate, typed or printed, and accompanied by reviews, the biographical sketch of the author, and a list of the author's basic papers and inventions.

New International Space Research Award Announced

The Prix Galabert, an annual international award for astronautical research, has been established under the auspices of the French Astronautical Society by H. Galabert of Monte Carlo. Winner of the 1959 award, which this year will bring the recipient 5000 new francs, or approximately $1000, is Maurice Allais of France, honored for his research on the paraconic pendulum and gravitation studies.

The prize will be awarded each year for research in one of the following astronautical disciplines: Astronomy, nuclear science, ballistics, aerodynamics, thermodynamics, electronics, materials, chemics, optics, celestial mechanics, corpuscular physics, geophysics, mathematics, astrophysics, physiology, and space law.

Candidates for the award are invited to send two copies of brief papers outlining the scope of research work done in any of these fields either to H. Galabert, 20 Bd. Princesse Charlotte, Monte Carlo, Monaco, or to the Société Francaise d'Astronautique in Paris.

Three BIS Symposia Planned

The British Interplanetary Society, in cooperation with other scientific groups, has organized three different symposia: A one-day "Symposium on Rocket and Satellite Instrumentation" to be held on September 1 at Manson House, 26 Portland Place, London, W.1; a one-day "Symposium on Space Navigation" on November 18 in the Lecture Theatre of the Royal Geographical Society, 1 Kensington Gore, London; and a two-day "Symposium on Rocket Propulsion" on January 6–7, 1961, at the College of Aeronautics, Cranfield. Further information may be obtained from The Secretary, BIS, 12 Bessborough Gardens, London, S.W.1.

Rocket Power

(CONTINUED FROM PAGE 22)

decision to use liquid hydrogen and liquid oxygen as propellants for chemical upper stages. We made this choice after much careful study and experimentation. We plan to use this combination in nearly all of our chemical upper stages in preference to other competitive combinations. Meanwhile, just to be sure we have not overlooked a breakthrough, we will continue research on other combinations, but at a lower level of effort and on a highly selective basis.

I think the contribution to reliability of amassing a large number of flights on a given vehicle is obvious. I want to add, though, that we do not subscribe to the "develop in haste and fix at leisure" route to reliability. In our kind of business such an approach is patently unacceptable. These devices have to work the first time they are launched or the entire cost of flights are wasted. NASA is reliability conscious to the point where I think some of our project people would be glad if they never heard the word again.

We have recently added a staff element, headed by Landis S. Gephart, to direct the NASA-wide reliability program. Our operating elements, such as the Marshall Space Flight Center in Huntsville, have engineering groups whose sole business is to insure that reliability is considered at every step—from conceptual design through detail design, selection of materials and components, development test, flight test, production quality control, and launch procedures—the entire spectrum of operations which influences the probability that complex launch vehicles, spacecraft, and all the myriad elements that make up the space-mission systems will function as intended.

Bet on a Winner

On the other hand, we cannot allow our desire for reliability to become such an overriding obsession that we timidly decide on the tried and true—and often obsolescent—approach in planning each new vehicle. That is why we have the third precept I mentioned. The tough job is to have *both* reliability and long, useful life. NASA is tackling this job by aggressively probing for real breakthroughs which promise large gains in mission capability. We bet heavily only after we have solid evidence that we have a winner. An example is the Rover program, about which I will say more later on.

Here I would like to discuss, very briefly, the vehicles we now have in our fleet and the standardized ones we are developing for the future.

As I mentioned earlier, we are still limited to the launch vehicles with which the U.S. began its space program, or their direct descendants. A few have been retired—the Jupiter C, which served so well back in 1958 when we greatly needed a U.S. satellite in orbit to repair, in some measure, our badly mauled prestige, and the Vanguard, which, in spite of its troubles, more than earned its development cost in the information provided by the three scientific payloads it orbited. In addition, it paid dividends by giving us upper stages for the Thor-Able, the Thor-Delta, and the Scout.

Also due to be retired this year are the Juno II, based on the Jupiter IRBM, and the Thor-Able. The Thor-Delta, which is a Thor-Able improved through the addition of coasting-flight attitude control and the accurate and flexible Titan radio guidance system, will be used through 1961 in a 12-vehicle program, but no follow-on procurement is planned.

All of these vehicles are destined to be replaced by two vehicles, the Scout and the Thor-Agena B—the Scout because of its relatively low cost (about

$750,000 per copy including all launching costs) and its high reliability potential; and the Thor-Agena B because of its combination of greater payload, flexibility of operation, and potential high reliability.

As to payload, Vanguard and Jupiter C could place in a 300-mile orbit about a 25-lb payload. The Juno II could perform the same mission with a 100-lb payload, the Thor-Able with 200 lb, and the Delta configuration with 480 lb. Of their successors, Scout can handle a 200-lb payload for a fraction of the cost, and the Thor-Agena B will be able to put 1250 lb in a 300-mile orbit.

The Agena B stage will also be used by NASA, as well as the AF, on top of the Atlas as a first stage. The Atlas booster will increase the 300-mile orbit payload capability of the Agena B to about 5300 lb.

Later in 1961, we are scheduled to launch our first Centaur. The Centaur will be the first vehicle to employ a high-energy upper stage; this liquid hydrogen-liquid oxygen stage is the first to employ a rocket engine developed primarily for space use. The added specific impulse afforded by hydrogen as a fuel gives the Centaur half again the payload of the Atlas-Agena B in a low orbit, and nearly three times as much payload when used as a lunar probe, which is one of its principal missions in the NASA program. For the first time, in Centaur, the U.S. has a launch vehicle able to duplicate the payload capability of the Sputnik vehicle.

Centaur's Importance

The Centaur is of major interest to DOD as well as to NASA. In fact, the Centaur performance objectives originally stemmed from the DOD requirements for a 24-hr communications satellite. The importance of the Centaur to NASA, however, is much more far-reaching than the capability of the Centaur vehicle itself, because of its relationship to Saturn. The Centaur upper stage will become a top stage for Saturn. In addition, four Centaur engines will power a Saturn second stage. In fact, liquid hydrogen begins to look as though it will dominate the launch vehicle upper-stage picture both as a fuel for chemical rockets and as a working fluid for nuclear rockets.

The Saturn vehicle is being developed under the management of the Marshall Space Flight Center. William Mrazek describes Saturn in the article on page 26. We have had a great deal of study and analysis in progress for the past year to try to define the vehicle which will follow the C-1 and C-2 Saturns. The principal mission which we have used as an objective in these planning studies has been that of landing a manned spacecraft on the moon and then returning a 10,000-lb re-entry package to the earth. The study has followed two principal approaches. The first was what you might call the brute-force attack, known as Nova.

There have been many references to Nova, as a vehicle, in the press and elsewhere. Nova is not a vehicle—it is simply one of a number of vehicle concepts which we have considered for the use of the $1^1/_2$-million-lb-thrust, single-chamber F-1 engine now under development for NASA at Rocketdyne. Under this brute-force approach, six of these large $1^1/_2$-million-lb-thrust engines would be used in the first stage. Four hydrogen/oxygen stages could be piled on top of this big booster to give us the 10,000-lb lunar-return package that we need.

This concept is beginning to face increasing competition from vehicle studies with nuclear upper stage rockets. Encouraging results from the initial Kiwi-A test last summer have raised our hopes that the large increase in efficiency which we get from using one or more nuclear upper stages, with weights less than one-third that of the Nova for the same mission capability, can be acquired by the time our program has reached the point where we need something beyond Saturn. Toward that end, NASA and AEC are increasing the pace of the Rover program, as the nuclear rocket program is known, aiming for an orbital flight test of a prototype nuclear rocket in 1965, with a Saturn launch vehicle.

NASA has developed, during the year and a half of its existence, a long-range plan. This planning effort has given our program, I believe, a clear sense of direction and pace.

As to direction, the major long-range goal of the NASA program is manned exploration, first of the moon and then the nearer planets. This goal focuses attention on the vehicle development program, the Mercury program and follow-on manned earth-satellite programs, preliminary unmanned explorations of the lunar surface, the variation of the space environment between the earth and the moon, and a host of related basic and applied-research projects. The space-science program gains direction and emphasis from this objective of ultimate manned lunar and planetary exploration. Also, our satellite-application program will continue to develop improved means of microwave communications and improved means of forecasting weather through meteorological satellites.

To carry out these programs, NASA will launch between 25 and 35 major vehicles and 100 sounding rockets a year over the next three years. Actually, in later years the pace of individual launchings may go down somewhat rather than increase, as we place in service the new, large, complex, and exceedingly expensive vehicles such as Saturn and its successors, each of which will have the payload capability of several of its predecessors.

I would like to summarize, then, by simply saying I feel we are embarked upon a broad, technically sound and logical program with definite goals in mind—our own goals. We are undoubtedly going to have our share of failures in this program—they have to be expected in this kind of work—and we will undoubtedly have to adjust the detailed timing and content of the program as we move along and learn more. But we do have a plan; we are getting good support from both the Administration and Congress; and I feel from my short experience with NASA that we have outstandingly competent people at all levels of the organization to supervise the program.

We were awfully late in getting started, but I feel we are now off and running. This is not a crash program I am talking about, but it is a vigorous and an aggressive program. My prediction is that in the long run it is going to prove sounder than a hysterical crash program trying to compete for spectacular propaganda "firsts."

♦♦

Mouse High

Norman Lee Barr, head of space environment research at Republic Aviation, watches a mouse being subjected to a simulated altitude of 10 miles in a chamber similar to the man-size one being built by Republic in its new space center.

Shape of Tomorrow

(CONTINUED FROM PAGE 25)

sents one of the many steps which we must take in the over-all evolution of spacecraft development.

To date, the U.S. lunar and interplanetary spacecraft have utilized the elementary technique of spinning the payload in order to achieve a degree of stabilization. However, experiments of the future call for full attitude stabilization. We must have long-life, continuously operating spacecraft, complete with all of the pertinent elements. These spacecraft must have their own propulsion and guidance systems for midcourse and terminal maneuvers. They must also have internal devices to generate power either from solar cells or from nuclear sources. They must have continuous three-axis stabilization either through some sort of reaction jets or momentum-wheel exchangers. They must have preprogrammed information stored away as a basis for future action. They must carry logic circuits to perform particular missions which vary in accordance with the conditions. They must have communication systems utilizing the available power and bandwidth in the optimum, and thus highly directional antennas in order to increase the gain and consequently to increase the information which can be transmitted. And the new spacecraft must carry payloads of scientific or engineering experiments to increase our knowledge of the space about us and far away from us and to help define the problems these environments present.

At the present time, the Jet Propulsion Laboratory is concluding the design phase of the Ranger spacecraft. This spacecraft has a first set of the complete elements just enumerated. The actual flight version, shown on page 24, will be about 12 ft long and will weigh 700 to 800 lb. It will be launched by an Atlas Agena-B rocket.

The first Ranger flights are now scheduled for next year. The initial effort will concentrate on perfecting the various engineering elements of the system, and will involve attempts to achieve long operating life. At the same time, they will carry some scientific equipment geared to obtaining a comprehensive survey of the radiation particles in space and the factors which influence them—a rubidium-vapor magnetometer, an ionization chamber, solar-corpuscular-radiation detectors pointed in different directions and with different sensitivities, a Lyman-α telescope which looks back at earth to examine the nature of the hydrogen clouds surrounding it, etc.

In subsequent flights, this same basic spacecraft will be used as a bus to carry a capsule to the moon. Just recently, JPL let a contract with the Aeronutronic Div. of Ford Motor Co. to develop the survival capsule to ride on this bus. The scientific package on the front of the Ranger spacecraft will be removed and the capsule will be mounted on the hexagonal surface. A midcourse propulsion system will be added to the main vehicle, or bus, to provide a maneuver part way out on the trajectory to insure a lunar impact of the capsule. As the bus approaches the moon about 66 hr after the launch, it will orient itself so that a TV camera will take a series of pictures with improving resolution as the bus approaches the moon. The bus will also carry a gamma-ray spectrograph which will allow us to obtain a preliminary analysis of some of the fundamental elements on the moon and thus help to determine what type of material it is made of. About 20 miles above the surface of the moon, the capsule will separate from the spacecraft bus and, with the aid of a solid-propellant retrorocket, slow down the approach of the capsule from about 6500 to 200 mph, as indicated in the sketch on page 25.

Inside the Capsule

The capsule proper, containing the instrumentation, will be protected by crushable structures to withstand an impact of 1000 g. Within the capsule will be an accelerometer to measure landing impact, a thermometer to measure the temperatures on the surface of the moon, and a seismometer to measure moonquakes and meteor impacts. It will also contain a power supply, transmitter, and radiating antenna for a total weight of about 50 lb.

The Atlas Agena-B that will launch Ranger was optimized to provide earth-satellite capabilities, and is usable at lunar distances. However, it cannot carry significant loads up to the velocities necessary to go to either Venus or Mars. Therefore we are looking forward in late 1962 to utilizing the Atlas-Centaur configuration to send spacecraft to Venus and Mars. These spacecraft will use the same basic elements that have been developed in the Ranger tests just discussed.

When this spacecraft makes a trip past Venus, it will carry equipment to try to learn more about the atmosphere of Venus and to try to penetrate through that atmosphere to learn more about the planet itself. Typical of the instruments which will be carried on board are the following: Ultraviolet spectrograph, a light-polarization detector, a passive (temperature) radar, an active radar, a magnetometer, a solar-corpuscular-radiation analyzer, a cosmic-ray detector, and an infrared scanner.

When the spacecraft makes a trip past Mars, in place of the passive and active radar it probably will carry equipment to obtain a detailed infrared picture mosaic. The picture will be broken up into a number of reasonably small squares and the infrared response within each square will be indicated. Thus, it should be possible to determine something about the forms of plant life which might be on Mars. This Mars spacecraft will probably also take a photograph of Mars from a few thousand miles away to increase our knowledge of the planet in the visual spectrum.

The Atlas-Centaur combination provides us with a capability of lifting approximately a ton of equipment to the vicinity of the moon. By appropriate use of retrorockets and capsules, this means that we can have lunar orbiters with several hundred pounds of instruments or we can soft-land about 100 lb on the lunar surface.

The year 1960 will see our national effort move from the dream to the design stage for these lunar soft-landers and orbiters.

In addition, effective utilization of the weight-lifting capability of the Saturn, discussed on page 26, is providing many interesting challenges in terms of basic mission decisions, corresponding system designs, reliability, economics, and many other factors.

Although these projects may lack "science-fiction appeal," consider how they would have sounded a scant 10 years ago. ♦♦

Just the Prelude

NASA Astronaut M. Scott Carpenter, in helmet, talks over a mockup of the Project Mercury communication system in the Collins Radio labs at Cedar Rapids, Iowa, which he recently visited on a familiarization tour. Contractor for the complete communications system, Collins has delivered five of the twenty on order to McDonnell Aircraft.

ASTRONAUTICS Data Sheet — *Materials*

Compiled by C. P. King, *Materials and Process Section, The Marquardt Corp., Van Nuys, Calif.*

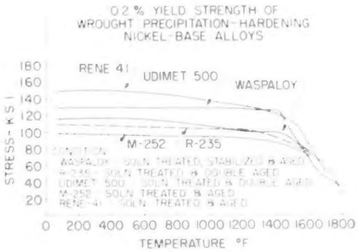
WROUGHT PRECIPITATION-HARDENING NICKEL-BASE ALLOYS

The metals included in this group are among those frequently referred to as "super alloys." They are used primarily for their strength at temperatures ranging from 1200 F up to 100 F short of melting point. They all contain aluminum and titanium as precipitation-hardening agents and all are vacuum-melted. Resistance to oxidation and corrosion is excellent.

Fabrication

The optimum condition for machinability is solution annealed. However, in cases where these alloys are gummy, they should be machined in the fully heat-treated condition. Carbide tools should be used and low feeds and speeds employed so as to minimize work hardening. Grinding of the material after it has been fully heat-treated is preferable for finishing.

These alloys may be formed into sheet components by spinning, drawing, and other conventional methods. They are usually formed in the solution treated condition. However, they work-harden rapidly and need frequent intermediate anneals.



Welding

These alloys can be inert gas arc-welded, either manually or automatically, with or without filler material. Where filler material is used, it should be the same as the parent metal. Welding is done with the material in the fully solutioned condition. After welding, it should be re-solutioned for homogenization and stress-relief, then aged to develop maximum strength. Proper tooling is essential to prevent cracking.

Spot and seam welding are also possible with these alloys.

Heat Treatment

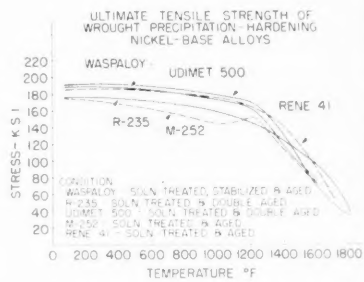
All of these materials employ a similar heat-treatment for development of optimum strength properties. Solution treatments vary in the range 1950 F to 2150 F and the material is then cooled in air. Subsequent aging is conducted between 1400 F and 1600 F, usually for about 16 hr. In some cases, a double age is used for best strength characteristics.

Applications

These alloys have found wide application in the turbojet engine field for such components as turbine casings, wheels and buckets, torque rings, afterburner parts, high-temperature bolts and fasteners.

Availability

Forgings, bar, billet, wire, sheet, and plate are produced of the metals comprising this group.



CUT ALONG THIS LINE

Physical Properties of Wrought Precipitation-Hardening Nickel-Base Alloys

	Density (lb/cu in.)	Coefficient of Thermal Expansion (Micro in/in/F)				Thermal Conductivity (BTU/sq ft/in/hr/F)	
		70–200 F	70–1000 F	70–1500 F	70–1800 F	at 70 F	at 1200 F
Udimet 500	0.290	6.25	7.30	8.36	9.70	76	142
Rene 41	0.298	6.70	7.50	8.45	9.35	65	146
M-252	0.298	5.90	7.20	7.75	—	79	135
R-235	0.296	6.70	8.00	8.70	9.65	63	144
Waspaloy	0.296	6.80	7.70	8.80	9.70	79	138

Chemical Composition of Wrought Precipitation-Hardening Nickel-Base Alloys

	C max	Mn max	Si max	Al	Ti	Mo	Cr	Co	Fe max	B	Zr
Udimet 500	0.15	0.75	0.75	2.50–3.25	2.50–3.25	3.00–5.00	15.00–20.00	13.00–20.00	4.00	0.080 max	—
Rene 41	0.12	0.10	0.50	1.40–1.60	3.00–3.30	9.00–10.50	18.00–20.00	10.00–12.00	5.00	0.003–0.010	—
M-252	0.10–0.20	0.50	0.50	0.75–1.25	2.25–2.75	9.00–10.50	18.00–20.00	9.00–11.00	5.00	0.001–0.010	—
R-235	0.16	1.00	1.00	1.75–2.25	2.25–2.75	4.50–6.50	14.00–17.00	2.50	5.00	—	—
Waspaloy	0.10	1.00	0.75	1.00–1.50	2.60–3.25	3.50–5.00	18.00–20.00	12.00–15.00	2.00	0.003–0.010	0.05–0.12

Rocket Catapult

(CONTINUED FROM PAGE 31)

end velocity imposes a tremendous transverse loading on the rocket, flat car, tracks, and so forth, as the entire unit proceeds through the vertical turn, or simply disappears into the ground!

The Juno-V booster would require a 4-mile run down a 45-deg slope and would experience over 30-g maximum transverse acceleration during pullout from a 1000-ft-radius curve! A pull-out curve having a radius in terms of miles would be required to maintain the maximum transverse acceleration within tolerable limits. This launching system appears to be more science fiction than scientific.

Electromagnetic Catapult: Another possible catapult energy source is electricity. The design of such a catapult is best described as a linear induction motor. The rotor segments are laid out as a track, with the necessary air gap; and a shuttle car connected to the missile is electromagnetically propelled along this rotor track. An alternator supplies the necessary electromotive force. The alternator is driven by a flywheel-motor-generator-gas turbine power chain.

Of historical interest is the Electropult, built by Westinghouse in 1943. The Electropult could launch a fighter within 340 ft, using an alternator with a 24-ton flywheel driven by a 750-kw DC motor.

Vast Power

Utilizing the electromagnetic catapult to launch the Juno-V booster represents 9.1×10^6 hp in 3.05 sec. At launch, the shuttle car may experience 10-percent slip, which means its synchronous motor speed is 1150 fps. It appears that if the system at launch has retained two-thirds of its original energy, near optimum operation results. Thus, the initial shuttle car synchronous speed is 1725 fps. The average synchronous speed is then 1438 fps. This average speed plus a probable 15-percent air-gap loss represents 1.5×10^7 hp, or 11.2 million kilowatts. A power factor of 70 percent yields the KVA rating of 16 million kilovolt-amperes or *ten times the output of the Niagara Falls hydroelectric plant!* Since the launch time is 3.05 sec, the final kinetic energy of the flywheel is 2.63×10^{10} ft-lb. This is only two-thirds of the initial kinetic energy of 3.95×10^{10} ft-lb (initial KE–final KE = $^1/_3$ initial KE). A 72-pole, 720-cps alternator would rotate at 1200 rpm. The radius of gyration of the poles, hub, shaft, and necessary rim weight (added "flywheel") would be on the order of 10 ft. Thus, the required weight of this unit is 1.6 million pounds. A 20,000-hp gas-turbine-generator-motor unit would drive the flywheel alternator. An estimate of the total weight including the rotor track, shuttle car, flywheel-alternator-gas-turbine-generator-motor, etc. is on the order of 25 million pounds!

Inertial Catapult: The inertial catapult utilizes a huge flywheel as an energy source and a gas-turbine generator-motor unit to drive the flywheel. The rocket is placed on a launch guide-track assembly, and a cable is connected to the missile and fed through pulleys to the flywheel. At launch, the cable is engaged to the rotating flywheel so that the cable windup tows the rocket to launch speed.

To provide a constant-acceleration launch with nearly constant flywheel "rpm," the launch cable must be wound up with increasing speed, since launch length is a function of time squared. Therefore, the flywheel's outer configuration would be paraboloidal. If the cable were engaged instantaneously to the rotating flywheel, the resulting peak load would be just short of infinite. Slippage, as in a friction clutch, would waste about 50 percent energy, but a fluid-drive clutch utilizing metal shot instead of hydraulic oil might better this performance. Even after complete clutch engagement, the cable would experience force oscillations as it stretched and slackened. This phenomenon requires a dampening system to eliminate any dangerous load oscillations. The required launch cable would have to be flexible enough to wind onto the flywheel, yet strong enough to withstand loads of over 10 million pounds.

The flywheel itself would be a rather massive component. Although the optimum flywheel design is a complex problem, a first approximation for a flywheel to launch the Juno-V booster would be approximately 30 ft in diameter by 12 ft high, rotating initially at 700 rpm and weighing about 3 million pounds. To further complicate the picture, the inertial launcher would require a 1500-ft guide structure.

Ferris-Wheel Launcher: The concept of the ferris-wheel launcher must be credited to M. Esnault-Pelterie. In theory, the ferris-wheel launcher was to consist of a large arm holding a counterweight on one end and the rocket on the other end. The ferris wheel would be rotated in a vertical plane by some external power source. After attaining the proper rim speed, the rocket would be released.

In this operation, the rocket mounts

Earth- and Lunar-Based Orbital Launcher Characteristics

Characteristic	Vertical Earth Launch	Vertical Lunar Launch	Horizontal Lunar Launch
Projectile weight*, lb	2200	2200	2200
Orbit altitude, miles	400	400	400
Orbital velocity, fps	24,700	4910	4910
ΔV for orbital injection, fps	920	920	920
ΔV to offset drag, fps	3000**	0	0
ΔV to offset gravity, fps	2470	1353	1030
Launch velocity, fps	29,250	5333	5010
Launch angle, deg	85	69	0
Launch acceleration, fps^2	3220	3220	3220
Launcher length, ft	130,000	4350	3700
Launch power, hp	5.97×10^6	1.07×10^6	1.0×10^6

* Including 200 lb of propellant for orbital injection rocket.

** Approximate.

Earth- and Lunar-Based Mission Velocities

Mission	Total Velocity, Fps — Earth Launch	Lunar Launch
400-mile orbit	30,170	5930
Lunar impact	39,700	...
Earth impact	...	7870
Venus landing	75,800	46,800
Mars landing	59,750	30,800
Ganymede landing	74,500	54,400
Saturn landing	170,200	154,200

normal to the rotating arm and thus experiences transverse acceleration loads during rotation. An arm miles in length would be required to provide proper launch speed and maintain the centrifugal force within tolerable limits. The counterweight would probably also have to be launched or the sudden unbalance would destroy the entire system.

Gun-Barrel Launcher: The latest concept for a gun-barrel launcher proposes a vertical shaft sunk deep into the earth. A series of explosive charges or gas generators strung out along the shaft would be sequentially fired to build up and maintain a pressure behind the rocket. The pressure propels the rocket like a piston to launch velocity at the shaft exit. The shaft ahead of the rocket might be evacuated to reduce aerodynamic drag, dynamic pressure, etc.

Alternate Plan

An alternate scheme would be to build a vertical tunnel from sea level through and to the top of a very high mountain, such as Mt. Everest, and thus eliminate a portion of low-altitude atmospheric drag and shaft-exit problems. For example, the atmospheric pressure and density at the top of a 29,000-ft mountain are, respectively, 69 and 60 percent less than that at sea level.

Digging a shaft hundreds or thousands of feet deep obviously is quite an undertaking. Lining the shaft with concrete is even a more difficult task. Creating a vacuum in the shaft and providing a cover which would open at the precise moment of rocket egress adds emphasis to the magnitude of engineering problems associated with this type of launch. A Pentagon official recently commented that, "The man who can come up with a way to dig a 100-ft-deep hole, 20 ft in diameter, for $50,000 is going to be digging more damned holes than this country has ever seen!"

Another gun-barrel launcher employs the exhaust gases of the rocket engines to build up pressure behind the rocket. A short "atmospheric" or nonvacuumized shaft is suggested. However, such problems as guiding the rocket out of the shaft while maintaining close rocket-shaft tolerances, the shaft acoustical problems, as well as the effects of back pressure on engine performance, are yet to be solved for this scheme.

The only gun-barrel launcher to achieve operational use was a mortar used by the German Army in WW II to launch the Rheinbote surface-to-surface missile (a 3780-lb solid-propellant missile with a 120-mile range). A powder charge launched the Rheinbote at a muzzle velocity of 788 fps; acceleration was limited to 500 g to prevent collapse of the rocket walls.

The inherent physical characteristics of a rocket-catapult launcher are just some of the problems facing the catapult designer. Two areas of equal importance are prelaunch and postlaunch functions.

The tower gantry, launcher, control center, and ground-support equipment are all integral parts in conventional launchings. Integrating them into a catapult launcher presents a formidable engineering task. During the countdown and holddown period, the catapult launching system must be capable of instantaneous activation over an extended hold period; and, in case of an aborted flight while the rocket is in the launcher, the launcher system must be capable of instantaneous deactivation with at least the same degree of rapidity and safety as that inherent in today's Titan launching system. ("Deactivation" implies that the launch system must be capable of detecting any missile or launcher malfunction during the launch phase and immediately implement the required safety measures.)

Ironic Twist

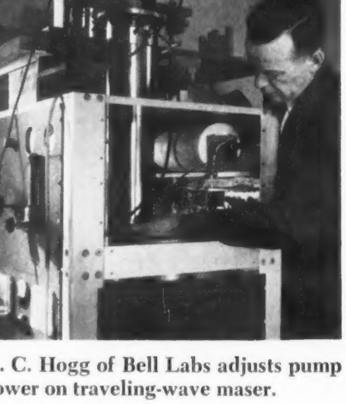
It is ironical that the objective of a catapult launcher to impart a launch velocity to a missile is one of its greatest disadvantages. During the passage of a conventionally launched missile through the atmosphere, the flight parameters of drag, stagnation temperature, and dynamic pressure increase to a maximum and then decrease to a minimum as the outer fringes of the atmosphere are reached. Normally a missile will be flying at approximately 1500 fps when these maximum forces occur. To employ a catapult and further increase a missile's velocity in the lower atmosphere only serves to increase the critical flight parameters and hence increase the structural design requirements.

For example, a Juno-V space vehicle conventionally launched might attain a maximum equilibrium stagnation temperature of 1000 F, a maximum dynamic pressure of 650 psf, and a maximum drag of some 90,000 lb during its atmospheric flight. Adding 1000 fps catapult-launch velocity and assuming a similar trajectory, these maximum flight conditions would increase to approximately 1400 F, 1400 psf, and 175,000 lb of drag. Thus, a launch velocity equal to 4 percent of orbital (burnout) velocity has increased the maximum temperature, pressure, and drag terms by 40, 132, and 95 percent respectively, while increasing the theoretical payload only some 11 percent.

For these reasons, the concept of catapulting large rockets from the earth is not practical.

On the other hand, this technique might be very effective on the moon or comparable celestial bodies possessing little atmosphere and where the gravity force is a small fraction of the earth's (see tables on page 93). A catapult on the moon could be used to launch manned vehicles, antivehicle projectiles, and translunar missiles and cargo carriers. It might launch scientific probes, projectiles aimed at earth targets, and unmanned tankers carrying lunar-mined and -processed propellants on space refueling missions. ♦♦

Masered Low-Noise Antenna Study



D. C. Hogg of Bell Labs adjusts pump power on traveling-wave maser.

Bell Telephone Laboratories has tested an antenna and receiver having a lower noise temperature than any complete receiving system yet demonstrated. This Bell work is part of an experimental program paving the way for a transoceanic communication system that will reflect electromagnetic signals from passive earth satellites.

The Bell receiving system comprises a highly directional narrow-beam horn antenna coupled to a traveling-wave maser that amplifies in one direction only. With the antenna pointed vertically skyward, over-all input temperatures as low as 17.6 K have been attained at 5.65 kilomegacycles in recent experiments. This figure comprises the noise contribution of the sky, antenna, and maser preamplifier.

NEW PRODUCTS CATALOGUE

EQUIPMENT . . . PROCESSES . . . MATERIALS . . . LITERATURE

Accelerometers

Linear, Low Frequency. Two additions to Series 7 line; one a frictionless differential-transformer unit (Model 7-55), with self-contained oscillator-demodulator for DC input and 0-5 v DC linear output; the other a potentiometer pickoff unit (Model 7-54) with mechanical linkage. Both oil-damped, in several operating ranges. **Edcliff Instruments**, Monrovia, Calif.

Ring-Shaped. Model 2221, frequency response from 2 to 4000 cps $\pm 5\%$ with 1000 megohm output; 0.6 in. in diam and 0.43 in. high; wt, 11 grams; temp range, —40 to 230 F. **Endevco Corp.**, Pasadena, Calif.

Miniature DC. A tough little $2^1/_2$-oz unit (Model 24155) with DC output for telemetering; standard ranges of ± 2 to ± 25 g; fluid-damped; potential resistance of 2000 to 5000 ohms. **Giannini Controls Corp.**, Pasadena, Calif.

Integrating. Digital output gives calibrated distance traveled along vector axis; 10^5 dynamic range; inputs to 100 g; accuracy of output, 0.1%; meets MIL-E5272B; eats 5 w from 28 v DC. **Globe Industries Inc.**, Albuquerque, N.M.

Thin. Smaller than a dime, particularly suited to wind-tunnel testing; range of 0.5 to 500 g and 3 to 4000 cps; temp range, —65 to 250 F. **Gulton Industries Inc.**, Metuchen, N.J.

Small 3-Axis. With potentiometer output; wt, about $^1/_2$ lb; $2^1/_4$ in. diam by 2 in. long; hermetically sealed; temp range, —65 to 180 F; takes 75 g on any axis. **Humphrey Inc.**, San Diego, Calif.

Leak-Tight Volume Compensator. For oil-filled accelerometer; a dual bellows assembly compensating 0.48 cu in. between —65 and 200 F with midpoint at 68 F and 1 atm. **Metal Bellows Corp.**, Canoga Park, Calif.

Linear, Unbonded Strain Gage. Responds flat with $\pm 5\%$ from static to 830 cps; ranges from ± 7.5 to ± 150 g; nominal output of ± 20 mv; temp range, —40 to 200 F. **Statham Instruments Inc.**, Los Angeles, Calif.

Antennas

Microwave-Pattern Testing Range. An indoor antenna-pattern testing range that gives one- and two-way performance data from 2500 to 26,500 mcs; 11-ft octagon about 40 ft long. **Budd-Stanley Co.**, Long Island City, N.Y.

Parabolic Antennas. A line of solid spun-aluminum reflectors and hop-stretcher feeds; 2, 4, 6, 8, and 10 ft in diam; max. rf performance in 7000-mc band. **Gabriel Electronics**, Millis, Mass.

Prefabricated Antenna System. Available in various degrees of complexity, with 40-ft antenna, for colleges and universities. **GB Electronic Div.**, Hook Creek Blvd., Valley Stream, N.Y.

Additional information about any of the products, equipment, processes, materials and literature listed on these pages may be obtained by writing to the New Products Department, ASTRONAUTICS, 500 Fifth Avenue, New York 36, N. Y.

Antenna Reel. A motor-operated radio antenna reel for supersonic aircraft; wt, 6.5 lb; unreels to 150 ft, brake-halted at any point. **General Controls A/E Div.**, Burbank, Calif.

Antenna Arrays. Two 20:1 arrays, direction finding with wide-band and medium gain, and log-periodic for nonfrequency-sensitive broad-band and complete-azimuth coverage. **Granger Associates,** Palo Alto, Calif.

Low-VSWR Antenna. For high-speed aircraft; with resin-fiberglass sleeve; wt, $8^1/_4$ lb; at 80–400 mc, has VSWR less than 4:1; at 70–420 mc, less than 7:1. **Land-Air Inc.**, Chicago, Ill.

Antenna for WWV-WWVH Reception. Three-element beam antenna of hurricane construction designed to improve long-path reception of NBS signals on 10, 15, and 20 mc. **H. George Bloch Inc.**, St. Louis, Mo.

Telescoping Rocket Antennas. Expanding antennas for rockets, satellites, etc.; stored length, 18 in.; expansion to 10 ft; flush doors explosive-actuated to release; motor-driven for the expansion. (Illustrated.) **Raymond Engineering Laboratory Inc.**, Middletown, Conn.

Transmitting Antennas for Tests Ranges. Rugged aluminum paraboloids up to 10 ft in diam for outdoor microwave test ranges; with equally rugged family of feeds. **Scientific-Atlanta Inc.**, Atlanta, Ga.

Slip-Ring Assemblies. Large antenna slip rings meeting MIL Std 5400C; available with hermetically sealed bearing housings; circuit noise level, S/N of 200. **Slip Ring Co. of America,** Los Angeles, Calif.

Blade Antenna. Omnidirectional for modern aircraft, broadbanded with VSWR of 2:1 from 117 to 143 mc; wt, 24 oz. **Tamar Electronics Inc.**, Santa Monica, Calif.

Computers

Table-Top Analog. Modular in design, easily expandable to full complement of 64 amplifiers; basic reference of 100 v. **Applied Dynamics Inc.**, Ann Arbor, Mich.

Digital Memory Drum. Magnetic, with true flux-responsive readout independent of drum speed; output directly usable for logic action; rugged; nondestructive recovery of stored information. (Illustrated.) **Consolidated Controls Corp.**, Bethel, Conn.

Desk-Size, Transistorized. Computes in microseconds and can execute 60,000 instructions in 1 sec; based on modules and a magnetic-core memory for speed and versatility. **Control Data Corp.**, Minneapolis, Minn.

NOR Logic Circuit. A balanced resistor network, encapsulated, size of matchbox; terminals for printed circuit or plug. **Dale Products Inc.**, Columbus, Neb.

Modules. Digital building blocks, 10 basic types and 15 variations, each containing 35 standard components/cu in., epoxy encapsulated; for forming computers and related equipment. **GM Delco Radio Div.**, Kokomo, Ind.

Automatic Core Tester. For production-line testing of magnetic cores; tests 3 per sec, as assembled in planes or stacks. **Digital Equipment Corp.**, Maynard, Mass.

Digital. Completely transistorized digital computer capable of both conventional data handling and scientific and control applications; averages 10,000 operations per sec. **General Mills**, Minneapolis, Minn.

Libragal. Airborne digital computer for launching and guiding missiles; air-cooled sandwich logic cards. (Illustrated.) **Librascope**, Glendale, Calif.

Rate-of-Change. Self-contained drawer-size computer measures temperature changes directly from thermocouples, neutron flux from counters, etc.; connects in parallel without causing overloads; no drift; drives strip charts directly. **Magnetic Instruments Co.**, Thornwood, N.Y.

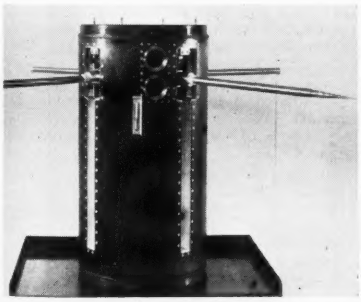
Shift Registers. A series of flexible magnetic shift registers with nondestructive readout, reversible data flow, "wide-width" bit coupling, one core per bit. **Magnetics Research Co.**, White Plains, N.Y.

Megacycle Rod Memory. Developed around NRC magnetic rod concept; NOTS to use it as a computer buffer memory for sequencing and control in the Naval Ordnance Data Automation Center, replacing flip-flop registers. (Illustrated.) **National Cash Register Co.**, Hawthorne, Calif.

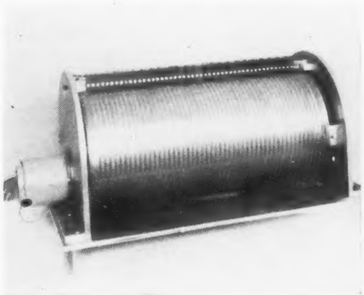
Solid-State Core Tester. Fits standard relay rack; starts, stops, or restarts from any address with any word pattern. **Packard Bell Computer Corp.**, Los Angeles, Calif.

Coincident-Current Magnetic Memories. Feature apertured ferrite plates or core arrays; random access with range from 128 to 4096 words and 4 to 64 bits per word. **Rese Engineering Inc.**, Philadelphia, Pa.

Decade Counter. A transistorized 100-kc add-subtract decade counter with simple switching

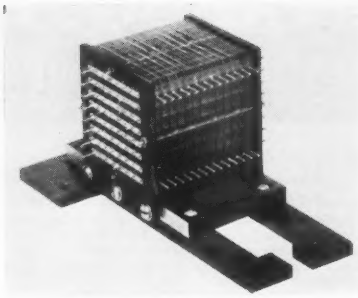


Telescoping Antennas on an Aerobee

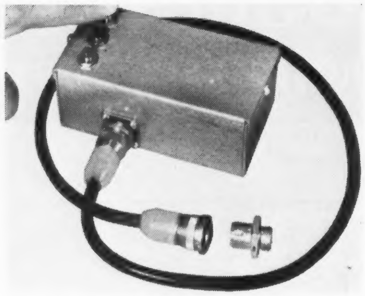


Digital Memory Drum

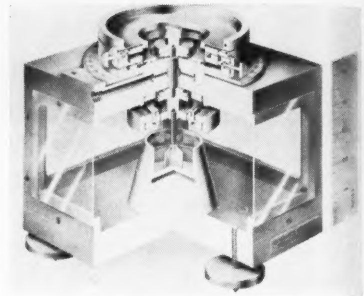
Libragal Logic Card



Megacycle Rod Memory



Initiator



Torque Tester

control; wt, 3 oz. **Robotomics Inc.**, Phoenix, Ariz.

Solid-State Analog Computer. In experimental form; a solid block of vacuum-deposited materials simulating components of a standard analog computer, using standard inputs and outputs. **Servomechanisms Inc.**, Hawthorne, Calif.

Analog Computer. Features continuous real-time solutions for computation and industrial controls; solid-state circuitry. **Southwestern Industrial Electronics Co.**, Houston, Tex.

Dynasort Correlator. "Low-cost" information processing equipment, for such things as sorting automatically delivered messages on basis of content. **USI Robodyne Div.**, Washington, D.C.

Explosive Components

Switch. Breaks six circuits at once; 2 x 1 x $^1/_2$ in.; wt, $1^1/_2$ oz; function time of approx. 4-5 ms; delivers force of 10 lb over 0.025 in. **Dial Service and Mfg. Inc.**, Cleveland, Ohio.

Initiator. Consists of power supply operated by 45 v DC batteries, high-voltage transmission cable, and an EBW initiator; voltage output tailored to exploding-wire requirements; electronic switch. (Illustrated.) **McCormick Selph Associates**, Hollister, Calif.

Arm/Safe Initiators. A series of designs in various configurations for ordnance, missiles, rocket motors, and space vehicles. **McCormick Selph Associates**, Hollister, Calif.

Pyrindicator. Substitutes in system and simulates explosive component by showing that circuit has operated. **McCormick Selph Associates**, Hollister, Calif.

Ballistic Actuators. A series with either push or pull action, force output to 25 lb and various stroke lengths; wt, 4 grams; fires at 28 v from input of 15,000 erg. **Propellex Chemical Div., Chromalloy Corp.**, Edwardsville, Ill.

Guidance, Gyros

Miniature Package. Consists of three floated rate gyros (Type RG-101) and two floated pendulous accelerometers (Type TA-400); withstands 150-g shock and 30-g vibration to 2000 cps without damage; can be checked remotely; size of small camera. **Fairchild Controls Corp.**, Hicksville, N.Y.

Rate Gyro. DC powered for flight-test vehicles, Model 36128 VN is available in ranges from $\pm$15 to 1000 deg/sec; motor life over 1000 hr; measures 2 by 4 in. **Giannini Controls Corp.**, Pasadena, Calif.

Pyrotechnic Gyro. Rotor spun at speeds up to 36,000 rpm by solid-propellant gas generator; max speed in 0.1 sec; wide range of rates; wt, 0.5 lb. **Giannini Controls Corp.**, Pasadena, Calif.

Electric Free Gyro. Has 2 deg of freedom; wt, 250 grams; 2 x $2^1/_2$ in. over-all; Scorsby Drift of 1 deg per min max; outer gimbal readout. **Greenleaf Mfg. Co.**, St. Louis, Mo.

Squib-Actuated Gyro. One-shot gyro, 4.5 x 2.75 in. over-all, weighing 800 grams, actuated by squib in 50 ms, with automatic uncaging. **Greenleaf Mfg. Co.**, St. Louis, Mo.

Dual-Axis DC Rate Gyro. In rate ranges from 50 to 2000 deg/sec; comes with 28 or 12 v DC motor; 4 in. long and 1.75 in. in diam. **Humphrey Inc.**, San Diego, Calif.

Drift Angle Indicator. Constructed in accordance with ARINC Characteristic 540 and designed specifically for commercial aircraft; ground speed given on a 3-drum counter, drift angle on calibrated dial; over 2000 hr operation. **Kearfott Div.**, Little Falls, N.J.

Small Rate Gyro. Weighs 6 oz and provides constant damping without heaters; employs quadrilever spring; length, $2^5/_8$ in.; temp range, —65 to 250 F. **Minneapolis-Honeywell Regulator Co.**, Boston, Mass.

Air-Bearing Torque Tester. A high-precision machine measuring torque to 0.1% of full scale; initially developed to test reaction of precision microsyn pickoffs, it appears to have many possible uses, e.g., testing gyro motors, torsion wires, etc. (Illustrated.) **Dynamics Research Corp.**, Stoneham, Mass.

Optical Equipment

Hydrogen Arc Illuminator. Light source based on Sylvania's new air-cooled hydrogen lamp; fits B&L and custom instruments. **Bausch & Lomb Optical Co.**, Rochester 2, N.Y.

Electronic Flash Unit. Compact, portable; delivers single flash of cold light for high-speed framing cameras. (Illustrated.) **Beckman & Whitley, Inc.**, San Carlos, Calif.

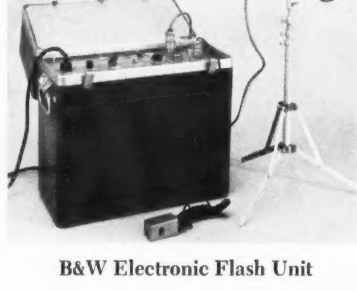
Photocell and Amplifier Unit. For aerial photography at night; picks up photoflash-cartridge signal and subsequently starts camera system. **Hycon Mfg. Co.**, Pasadena, Calif.

Micro-Master 105/35 mm Camera-Projector. Completely motorized; changes negatives automatically; motorized filter in optical system; allows interruption of filming sequence to take a single frame of any size; and many other features. **Keuffel & Esser Co.**, Hoboken, N.J.

Micro 'Dapter. Adapts cameras to most microscopes or telescopes; allows normal operation of camera shutter. **Lafayette Radio**, New York, N.Y.

Closed-Circuit-TV Camera. Completely transistorized camera and control unit for regular TV receiver or video monitor; low cost claimed. **Packard Bell Electronics**, Los Angeles, Calif.

Visual Recording Camera. 4.5-lb helmet camera, simultaneously records wearer's eye movements and object seen. **PAR Products Corp.**, Santa Monica, Calif.



B&W Electronic Flash Unit

Power Supply

Armour DC Power Supplies. Two new transistorized models—outputs from 0-10 v to 0-150 v and current ratings from 0-0.75 amp to 0-30 amp. **Armour Electronics**, Los Angeles, Calif.

Vibration-Proof Battery Holders. For D-size mercury batteries; insulated ends, locking strap, various holder platings, flush mounting, etc. **Cambridge Thermionic Corp.**, Chestnut Hill, Mass.

Silver-zinc Missile Battery. Dual battery in single case; each 19-cell section provides 3 amp at 26.5 v; capacity, 2 amp-hr. **Cook Batteries**, Denver, Colo.

Four-Channel Power Supply. Model P617B transistorized 35-lb constant-current reference; output ripple less than 1 percent RMS and regulation better than plus or minus 0.5 percent. (Illustrated.) **ITT Industrial Products Div.**, San Fernando, Calif.

Brushless Synchronous 400-Cycle Generators. In 60- to 400-cycle models to provide precise 400-cycle power in rating from 7.5 to 150 kva. **Leach Corp. Inlet Div.**, Compton, Calif.

Sprague DC Power Supplies. Based on silicon-diode rectifiers and transistors; eight models over the current range 100 to 1500 amp, 14-36 v; transistor-magnetic control. **Sprague Engineering**, Gardena, Calif.

Pressure Transducers

Bellows-Type. Low-capacity series with terminal linearity within 0.1% full scale; capacities of $\pm$15, 30, and 60 psi; standardized performance. **BLH Electronics Instrumentation Div.**, Waltham, Mass.

Absolute-Pressure. Subminiature model, ranging 0-350 to 0-3500 psia, with static error band as low as $\pm$1% and temp range of —100 to 200 F; wt, 4 oz. **Bourns Inc.**, Riverside, Calif.

Vibration-Resistant. Model 725, a 35-g absolute-pressure unit, gives error of only 1.5% under vibration in sweeps from 30-50 g, 25-2000 cps; about 2 x 1 in.; in 10 pressure ranges. **Bourns Inc.**, Riverside, Calif.

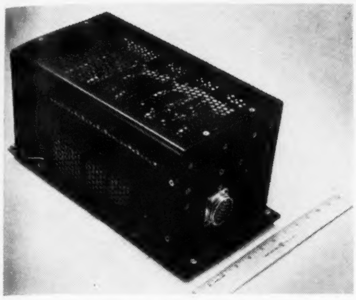
Type R. Series based on Ni-Span-C Bourdon tube, with balanced mechanical system, provides temperature stability of 0.01% per deg F over the range $\pm$65 to 350 F; vibration resistant; ranges of 0-100 to 0-5000 psig; small pancakes weighing about 3.5 oz. **International Resistance Co.**, Philadelphia, Pa.

Quartz-Pickup. Rugged, coolable; high sensitivity and very fast response; measures variations of 0.1 psi over range of 5000 psi; special models to 10,000 psi; $^3/_8$ x 1 in.; n.f. of 100,000 cps. **Kistler Instrument Corp.**, Tonawanda, N.Y.

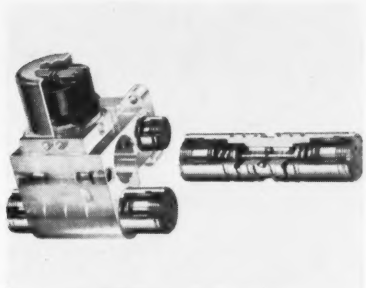
DC-Output. Model CP51 combines variable reluctance and carrier demodulation; outputs of 0-5 v DC or 0-1 ma; ranges from 0.5 to 1000 psi, diff. gage, or abs.; accepts corrosive liquids and gases. **Pace Engineering Co.**, North Hollywood, Calif.

Potentiometer. Pressure ranges from 0 to 100 psia or psig; wiper arm moved by electromagnet; multiple commutation; wt, 15 oz; linearity, 0.75% between —65 and 200 F. **Physical Sciences Corp.**, Pasadena, Calif.

Circular Diaphragm. Transducers based on a free-edged circular diaphragm of Ni-Span-C in the sensor; full scales of 1-100 psia; differential or absolute measurements; sensitive to less than 0.01% of full scale. **Rosemount Engineering**



ITT Four-Channel Power Supply



Electrohydraulic Servo Valve

Co., Minneapolis, Minn.

Vibration-Resistant. Series covers range of 0-800 and 0-5000 psia; total static error of 1% and vibration band less than 1.75% at 35 g; fluid viscosity adjustable for damping. **Servonic Instruments Inc.**, Costa Mesa, Calif.

High-Pressure. Stainless-steel cased; wt 6 oz; ranges between 1000 and 5000 psi; dynamic error band of $\pm 2\%$. **Servonic Instruments Inc.**, Costa Mesa, Calif.

Damped. Subminiature absolute-pressure transducer; ranges from 50 to 5000 psia; very short rise time; nonlinearity and hysteresis less than ± 1 full scale; wt, 3³/₄ oz; compensated temp ranges. **Statham Instruments Inc.**, Los Angeles, Calif.

Stackable. Subminiature units include absolute, gage, and both bi- and unidirectional action; ranges of 0-5 to 0-5000 psia; compenated temp range, −65 to 250 F; wt, 4 oz. **Statham Instruments Inc.**, Los Angeles, Calif.

Wide-Range. Model 226 features pressure cavity cleanout, infinite resolution, and overload protection; ranges of 0-300 and 0-2000 psi with 0.1% repeatability and linearity of 0.25% from −100 to 275 F. **Taber Instrument Corp.**, North Tonawanda, N.Y.

Airborne. Miniature units based on one-piece Ni-Span-C proving ring bonded to four precision strain gages; ring acts as heat sink in zero-gravity conditions; ranges to 1000 psi; 0.25% accuracy; handles corrosives; rugged; high overload capacity. **Taber Instrument Corp.**, North Tonawanda, N.Y.

Variable-Reluctance. Rugged 12-oz instrument covering ranges from 0-5 to 0-5000 psi; DC in and DC out; infinite resolution, highly stable, no moving parts. **Tavis Engineering**, Monrovia, Calif.

Overpressure. Transducers with ranges from 0-25 to 0-300 psi that can withstand overpressures of 1500 psi without shift or damage; no auxiliary cutoff valving; about 3 x 3 in. **White Avionics Corp.**, Long Island, N.Y.

Expanded-Scale DC. Model P2-1253 functions over specific portions of a range, e.g., 475 to 550 psi, with full 0-5 v DC output; accuracy, better than 0.15% of pressure. **Wiancko Engineering Co.**, Pasadena, Calif.

Pumps and Valves

Hydraulic Pump. For aircraft and missiles; delivers 27 gpm at 3750 rpm and 3000 psi; weighs 17.5 lb; meets MIL-P-7740B and MIL-P-19692. **American Brake Shoe Co., Kellogg Div.**, Rochester, N.Y.

Vertical Centrifugal Pumps. Available in capacity from 5 to 500 gpm at heads from 10 to 120 ft and settings from 3 to 16 ft; available in 17 alloys. **Dean Brothers Pumps Inc.**, Indianapolis, Ind.

Hydraulic Safety Lock. For high-pressure systems; fits in hydraulic cylinder inlet and actuates if there is a line failure. **Ground Systems Inc.**, El Monte, Calif.

Pressure Controller. Integral system of mechanical pressure regulator, micro-adjustment, and servo system that precisely adjusts to desired pressure and compensates for drift. **Hass Instrument Corp.**, Washington, D.C.

Electrohydraulic Servo Valve. For high-inertial-load systems; functions as flow-controller statistically and combines pressure and flow control dynamically. (Illustrated.) **Hydraulic Research and Mfg. Co.**, Burbank, Calif.

Pressure Equalizer. For lox expansion chambers; line of devices covers pressures up to 4000 psi, in sizes from 0.25 to 36 in. in diam; incorporates machined aluminum bellows. **Hydrodyne Corp.**, N. Hollywood, Calif.

Micrometer Flow-Control Valve. Rate of flow increases linearly tenfold through 15 turns of screw adjustment with micrometer precision. **Sanders Associates, Nashua, N.H.**

Switches

Pressure, High Safety. Model 5126, less than 3 in. long and ³/₄ in. in diam, with pressure range of 5-100 psig, takes 300% overpressure and will withstand 1000 F for 15 min. **Aero Mechanism Inc.**, Van Nuys, Calif.

Small Toggle. Series of subminiature, with overload protection, low contact resistance, and very light weight; SPDT, DPDT, and center-off; minimum life of 25,000 operations at 5 amp. **Allied Control Co.**, New York, N.Y.

Trans-Switcher. Compact 100-channel transistor switching unit detects signal changes in microsecs to use full response of sequence recorder; 5¹/₂ in. of rack height. **Brush Instruments**, Cleveland, Ohio.

Stepping. Type 210, for digital operation, weighs 1¹/₂ lb with 12 levels, capable of over 100-million operations with twelve 10-pt levels, 300 million with four 30-point levels. **Reincke, Meyer, & Finn Inc.**, Chicago, Ill.

Pressure, Externally Adjustable. Nine rugged models, convert fluid pressure to electrical on-off signals, in ranges from 2 to 3000 psig, between −65 and 275 F, accurate within 2%. **Consolidated Controls Corp.**, Bethel, Conn.

Crossbar. Type P, suitable for video, audio, and sync switching, weighs 4¹/₂ lb, switches sequentially or at random up to 120 circuits. **James Cunningham, Son and Co.**, Rochester, N.Y.

Portable Switch Analyzer. For commutators or mechanical samplers; gives complete analysis of duty cycle, dynamic contact resistance, and phase relationships of every channel of every pole, displayed and measured on an associated oscilloscope; briefcase size. **Cushman Precision Industries**, Princeton, N.J.

Waveguide Control Box. Remote-control box gives positive transfer of DB-616 and 617 waveguide switches; lights show switching; dual set of relays; size, 8 x 8 x 11 in. **DeMornay-Bonardi**, Pasadena, Calif.

Digital, 16-Position. Dial-setting, 4-bit binary-coded output, in-line visual readout, modular construction, life of 1 million counts, special dial characters. **Digitran Co.**, Pasadena, Calif.

Switchlite, Transistorized. Low-voltage circuit triggering of neon indicators in one plug-in. assembly; extra sockets wired internally; lens tapered for easy removal. **Eldema Corp.**, El Monte, Calif.

Electromechanical Interlock. Variety of switching arrangements; based on five independent novel internal SPDT switches; sets to ± 0.010 in. of operating point; retaining pins withstand 3000-lb static side force. **Electroid Corp.**, Union, N.J.

Waveguide. Series, operate manually or electrically, covers frequency range of 3.95 to 40 kmc, each switch operating over full waveguide bandwidth. **FXR Inc.**, Woodside, N.Y.

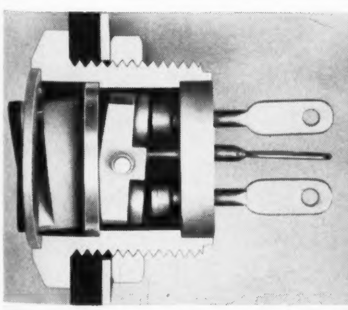
Coaxial Switch Ratiotrans. Subminiature ratio transformers, 2¹/₂ and 3¹/₂ in. in diam, feature 0.001% occuracy and linearity and up to six-place resolution. **Gertsch Products Inc.**, Los Angeles, Calif.

Mercury, Subminiature. Max length of ¹/₂ in., diam of 0.162 in., an ¹/₁₀ amp rating; SPST; differential angle of 15 deg. **Gordos Corp.**, Bloomfield, N.J.

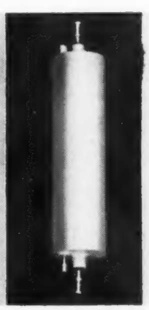
All-Magnetic Rotary Steppers. Series, for precise angular positioning of rotary components, operates on number of pulses received; can be used to transmit angular data to remote places. **A. W. Haydon Co.**, Waterbury, Conn.

Toggle, 4-Way. Designed for an aircraft navigational system, consists of four pairs of Haydon Series 5300 snap-action switches with rating of 5 amp resistive, 3 amp inductive at 30 v DC and 115 v AC. **Haydon Switch Inc.**, Waterbury, Conn.

Salt-Water-Actuated. When submerged, closes an electrical circuit to actuate squib and release



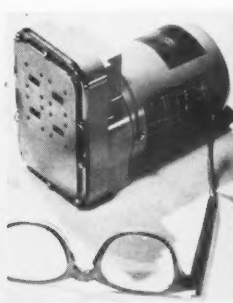
FluxLink



Acceleration Switch

ACTUAL SIZE

Klixon



K-, X-Band Transfer

Radiplex 89

compress gas automatically; AC or DC, 8-amp pass; actuates in 1 sec or less; wt, 0.3 lb. **Kidde Aero-Space Div.**, Belleville, N.J.

Switch with Voltage-Sensing Element. For switching from exhausted battery to fresh one or solar power; motor driven; no contact chatter vibrated from 5 to 2000 cycles, 40 g; 21 circuits in less than 14 cu in. **Kinetics Corp.**, Solana Beach, Calif.

Digimotor Rotary. In 10 switch decks; stepping rate of 6–8 pulses per sec or higher; meets MIL-E-5272; manual setting; magnetic anti-overcoast; unidirectional or bidirectional. **Ledex Inc.**, Dayton, Ohio.

Rotary Limit. Has 10-amp rating, weighs less than 0.16 lb; SPDT or DPDT; infinite operating-point adjustment; rugged; life over 20 million cycles. **Licon Div., Illinois Tool Works**, Chicago, Ill.

Overtravel Plunger. For cam actuation in rotary applications; meets MS-25085; less than 1 in. cu; operating force, 10 oz max; return, 1 oz min. **Milli-Switch Corp.**, Gladwyne, Pa.

Miniature Acceleration. Closes and resets at limiting acceleration; consists of gas-damped seismic system with range of ± 10 to 30 g, accuracy of $\pm 5\%$, repeatability of ± 0.5 g, temp range of −65 to 250 F; wt, 1 oz; size, $1^1/_2$ x $^1/_2$ in. (Illustrated.) **W. L. Maxson Corp.**, New York, N.Y.

Adjustable Pulse. Pulse-producing, snap-action model for controlling pneumatic valves; plunger adjustable to 0.750 in.; 4-lb operating force; no switch action on plunger return. **M-H Micro Switch**, Freeport, Ill.

Protected Plunger. A 0.2-oz environment-free miniature SPDT switch, elastomer seal around plunger, aluminum body; temp range, −65 to 230 F. **M-H Micro Switch**, Freeport, Ill.

One-Shot. Series of one-shot switch-circuit push-button assemblies; gives a single squarewave pulse synchronized with a clock pulse, with pulse frequencies of 4–500 kc; variety of voltages, rise times, etc. **M-H Micro Switch**, Freeport, Ill.

Millimicrosec. Mesa germanium transistor, features max power rating of 300 mw at 25-C case temp. **Motorola Semiconductor Products Div.**, Phoenix, Ariz.

Pushbutton. Serves as a patching field for a 10-wire control buss; features one-line pushbutton operation, positive locking of all line keys, and ruggedness; available with 5, 6, 7, 8, or 9 stack-ups. **Nems-Clarke Co.**, Silver Spring, Md.

Pressure. Snap action from fluids or gases; range from 0–500 psi; repeatability within $\pm 0.5\%$; Ni-Span-C element; rating, 6 amp at 125/250 v AC; temp range of −65 to 300 F; minimum life of 50,000 cycles; size, 1 x 1 in. **Pamar Electronics Co.**, Farmingdale, N.Y.

Radiplex 89. Direct, high-speed, all-electronic low-level multiplexer; handles 48 channels at 24 kc work rate; 10-microvolt resolution; operates at full-scale input range as low as ± 5 mv. (Illustrated.) **Radiation Inc.**, Melbourne, Fla.

FluxLink. A switching advance; seals contact arm in steel case and actuates it positively by magnetic flux; temp range from −65 to over 900 F; size, $^3/_4$-in. OD and $^5/_8$-in. length; rating, 0–15 amp, 125 v AC; three basic models. Many possible applications for this kind of switch, which has great inherent reliability. (Illustrated.) **Space Components Inc.**, Washington, D.C.

Switching Transistor. Germanium-alloy junction transistor takes shocks of over 20,000 g; performs critical switching functions at currents up to 400 ma. **Sylvania Semiconductor Div.**, Woburn, N.H.

Silicon Diode. With guaranteed max speed of 0.8 billionths of a sec and typical rating of 0.3 billionths. **Sylvania Semiconductor Div.**, Woburn, N.H.

Klixon. Miniature hermetically sealed switch cased in stainless steel and weighing less than 1/28 oz; snap-action W-blade element; sealed by seam and stitch welding; temp range of −65 to 275 F; capacity of 3 amp, 28 v DC, resistive; actuating force of 12 ± 8 oz and release of 1 oz; minimum life of 10,000 cycles. (Illustrated.) **TI Metals and Controls Div.**, Attleboro, Tex.

K- and X-Band Transfer. Can be operated as SPDT or double-throw transfer; motor-actuated; VSWR of 1.05, insertion loss of 0.07, and cross-talk of 80 db. (Illustrated.) **Transco Products**, Los Angeles, Calif. ♦♦

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